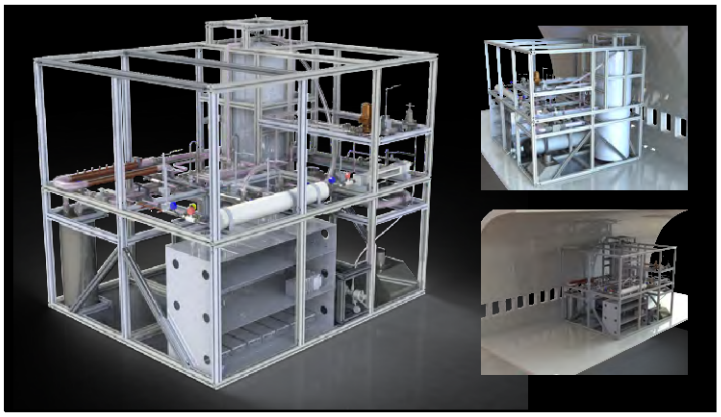
PURDUE UNIVERSITY | Mechanical Engineering

Spring 2022 Undergraduate Research Projects

Project Name:	Efficient and sustainable water technology	**Project ID:**	R001
Supervisor:	David Warsinger	**Number of Positions**	>2
Project Description:	Water and energy are tightly linked resources that must both become renewable for a successful future. However, today, water and energy resources are often in conflict with one another, especially related to impacts on electric grids. Further, advances in 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 membrane, artificial intelligence control algorithms, and thermodynamically optimized system designs. The students will be responsible for fabricating membranes, building hydraulic systems, analyzing data, modeling thermal fluid phenomenon, implementing control strategies in novel system configurations, academic and patent writing, and/or publication-quality graphics. More info on lab projects at: www.warsinger.com		
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.		
Weekly Working Hours	>10		
For Credits/Pay	For credit: 3 credits is typical For Pay: (Hourly rate) Vontuntary		
Desired Qualifications	Applicants should have an interest in several of these areas: thermodynamics, heat transfer, materials, water treatment, energy, and sustainability. Applicants with experience in some (not all) of the following are preferred: experimental design and prototyping, Python, LabView, EES, MATLAB, 3D CAD Software, & Adobe Illustrator. 2nd semester Sophomores, Juniors, and 1st semester Seniors are preferred. Strong preference for students staying for multiple semesters and/or sumemrs		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Liquid nitrogen parabolic flight facility	Project ID:	R002
Supervisor:	Issam Mudawar	Number of Positions	Up to 6
Project Description:	Professor Issam Mudawar, Director of the Purdue University Boiling and Two-phase Flow Laboratory (PU-BTPFL), and his research team are conducting extensive experimental work concerning phase change mechanisms in both Earth gravity and microgravity. Two of these projects involve investigation of flow boiling in tubes and spray cooling of liquid nitrogen in parabolic flight aircraft simulating microgravity. Findings from this effort are expected to impact several important space applications, including nuclear thermal propulsion systems, ascent stages, descent stages, in-space fuel depots, and transfer lines that cool space experiments. Prof. Mudawar is looking to recruit teams of up to six students (as undergraduate research assistants or single ME463 team) to assist in both CAD modeling (using SolidWorks) and design of the parabolic flight rig during the spring 2022 semester and beyond. U.S. citizenship in preferred due to the sponsor's requirements. If interested, please contact Prof. Issam Mudawar at mudawar@ecn.purdue.edu with short CVs and examples demonstrating your CAD skills!  CAD model of parabolic flight facility developed by ME463 team during Spring 2021.  Mudawar's Flow Boiling and Condensation Experiment (FBCE) being loaded into the Cygnus spacecraft, and preparations for August 10, 2021 launch to the ISS on board Northrop Grumman's Antares rocket. FBCE was initiated ten years ago as a parabolic flight experiment similar to the one described in this project announcement.
Final Deliverables:	Design Report		
Weekly Working Hours	Flexible		
For Credits/Pay	For credits: 3 credit hours		
Desired Qualifications	Very strong CAD skills using SolidWorks		

Project Name:	Thermal management of electronic devices	**Project ID:**	R003
Supervisor:	Justin A Weibel	**Number of Positions**	1-2
Project Description:	The continued miniaturization of electronic devices, with expanded functionality at reduced cost, challenges the viability of products across a broad spectrum of industry applications. Proper thermal management of electronic devices is critical to avoid overheating failures and ensure energy efficient operation, from supercomputers to electric vehicles. Research projects in the Cooling Technologies Research Center (CTRC) are exploring new technologies and discovering ways to more effectively apply existing technologies to addresses the needs of companies and organizations in the area of high-performance heat removal from compact spaces. One of the distinctive features of working in this Center is training in practical applications relevant to industry. All of the projects involve close industrial support and collaboration in the research, often with direct transfer of the technologies to the participating industry members.		
Final Deliverables:			
Weekly Working Hours	Flexible, and to be decided based on discussion with the supervisor.		
For Credits/Pay	Flexible, and to be decided based on discussion with the supervisor.		
Desired Qualifications	Projects in the Center involve both experimental and computational aspects, are multi-disciplinary in nature, and are open to excellent students with various engineering and science backgrounds. Multiple different research project opportunities are available based on student interests and preferences.		

Project Name:	Purdue Overclocking (OC) Group	**Project ID:**	R004
Supervisor:	Justin A Weibel	**Number of Positions**	Multiple
Project Description:	Computer overclocking takes advantage of thermal margins in electronic component designs to improve performance at the cost of increased power consumption and heat generation. Sponsored by the Institute of Electrical and Electronics Engineers Electronics Packaging Society (IEEE EPS) and hosted by the Cooling Technologies Research Center (CTRC), the misson of the Purdue Overclocking (OC) Group is to push existing computer hardware to its limit with novel cooling solutions. Each year, the Purdue OC group aims to develop a new cooling system (e.g., liquid nitrogen cooling) to compete in various overclocking competitions as well as IEEE's overclocking championship held at the IEEE ITherm conference. In past years, the group has run water cooled and liquid nitrogen pool boiling computers; this year, the group is designing, building, and testing a jet impinging liquid nitrogen cooling solution. For more information, see the group website: https://sites.google.com/view/purdueoc.		
Final Deliverables:	Deliverables include competing in both physical and virtual overclocking competitions, reporting performance benchmarks, and presenting design reviews of high performance cooling solutions.		
Weekly Working Hours	Flexible, and to be decided based on discussion with the supervisor and other team members.		
For Credits/Pay	Voluntary Only		
Desired Qualifications	Open to any interested students.		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Rheological study of fluids	**Project ID:**	R005
Supervisor:	Arezoo Ardekani	**Number of Positions**	1
Project Description:	Build and assist in performing experiments to study the rheology of different fluids.		
Final Deliverables:	Build an experimental setup to perform rheology, assist in data collection, and data post-processing using MATLAB to report the results.		
Weekly Working Hours	10 hours		
For Credits/Pay	For credits: (3 credits)		
Desired Qualifications	Junior/senior in Mechanical/Chemical engineering		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Nanoscale Heat Transfer	**Project ID:**	R006
Supervisor:	Xianfan Xu	**Number of Positions**	Up to 2
Project Description:	This project deals with study of heat transfer in very thin film materials (as thin as a few atomic layers) using advanced measurement techniques including Raman spectroscopy and ultrafast laser spectroscopy. Heat transfer in nanoscale materials shows superior characteristics for applications in numerous advanced electronic, photonics, and energy conversion devices. Their thermal transport behaviors are also different compared with bulk materials, and an understanding of the transport process is important for applications of these materials. We use non-contact, optical method (i.e., lasers etc.) to investigate heat flow in these materials. The undergraduate student will work with graduate students to learn to use state-of-the-art experimental facilities, carry out experiments, and analyze experimental results.		
Final Deliverables:	Summary Report		
Weekly Working Hours	10		
For Credits/Pay	For credits: (# of credits) 3 For Pay: (Hourly rate) Voluntary		
Desired Qualifications	Mechanical Engineering Junior or Senior standing with GPA > 3.5		

Project Name:	Nanoscale 3D printing	**Project ID:**	R007
Supervisor:	Xianfan Xu	**Number of Positions**	Up to 2
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 and testing of a setup for building 3D structures using a femtosecond pulsed laser. 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 setup incorporates the steps from designing a CAD model file to slicing the model in layers to generating the motion path of the laser needed for fabricating the structure. Possible improvements to the process by the undergraduate researcher include control algorithms, better CAD models, and better manufacturing strategies.		
Final Deliverables:	Summary Report		
Weekly Working Hours	10		
For Credits/Pay	For credits: (# of credits) 3 For Pay: (Hourly rate) Voluntary		
Desired Qualifications	Mechanical Engineering Junior or Senior standing with GPA > 3.5, CAD models (knowing Python is a plus)		

Project Name:	Nanotechnology	**Project ID:**	R008
Supervisor:	Jong Hyun Choi	**Number of Positions**	4
Project Description:	The research has two themes: (1) DNA nanotechnology and (2) 2D materials. Each theme has two open positions. (1) The DNA nanotechnology project aims to develop dynamic nanostructures from DNA and study their mechanics. (2) In the 2D materials project, we develop advanced materials for optoelectronics and energy storage devices.		
Final Deliverables:	Final presentation and monthly reports		
Weekly Working Hours	9-10 hours per week		
For Credits/Pay	For credits: (# of credits): 3 credits For Pay: (Hourly rate) Voluntary		
Desired Qualifications	Curious, responsible, hard-working students		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Polaritonic Energy Transport (PET Project)	**Project ID:**	R009
Supervisor:	Thomas Beechem	**Number of Positions**	3
Project Description:	**Who we are**… Specere is a latin word that means "to look or behold." That's what we do. We look, explore, and examine different ways to: (1) move energy with light and (2) get information from light. More specifically, we are a light lab employing infrared physics to create spectroscopic, thermal, and sensing solutions. **Research Topic, Polaritonic Energy Transport:** We seek to design materials capable of more effectively moving heat at extremely small scales like those in modern microelectronics. *Success will enable: more efficient data centers, power electronics like those in EV's, and new computing architectures*. ***What' You'll Do:*** Team members will be responsible for designing novel metamaterial stacks capable of maximizing heat transfer using a combination of computational modeling and experimental measurements of optical properties. Direct mentoring from Dr. Beechem will build your skills up in each area such that you will gain proficiency in advanced simulation (COMSOL) and spectroscopic tools (Raman, IR-ellipsometry). In addition, you will have the chance to participate in writing journal articles and pursuing patents based on your work.		
Final Deliverables:	Group Presentation outlining technical progress with associated "paper skeleton" outlining path to publication.		
Weekly Working Hours	15		
For Credits/Pay	For credits: (# of credits) 3		
Desired Qualifications	**Who we are seeking…** We look for motivated and hard-working undergraduates having both strong aspirations for post-graduate studies as well as those that are just "grad school curious." All applicants should be capable of working independently while effectively communicating within a team setting.		

Project Name:	Data-science for Fluid Dynamics	**Project ID:**	R010
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:	3D printing of bone models	**Project ID:**	R011
Supervisor:	Professor Thomas Siegmund	**Number of Positions**	1
Project Description:	Develop and realize 3D print model for the visualization of fractures in human cortical bone		
Final Deliverables:	A report, models		
Weekly Working Hours	6-9		
For Credits/Pay	For credits: 3 (# of credits) preferred For Pay: (Hourly rate): not available for pay Vontuntary: not available as voluntary position		
Desired Qualifications	ME UG student, CAD, interested in image processing, interested in research		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Machining with mini-mill	**Project ID:**	R012
Supervisor:	Professor Thomas Siegmund	**Number of Positions**	1
Project Description:	Install, program and deploy a small scale milling system		
Final Deliverables:	A report,		
Weekly Working Hours	6-9		
For Credits/Pay	For credits: 3 (# of credits) preferred For Pay: (Hourly rate): not available for pay Vontuntary: not available as voluntary position		
Desired Qualifications	ME UG student, CAD, G-code, machine shop, interested in research		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Fracture Mechanics with LEGO structures	**Project ID:**	R013
Supervisor:	Professor Thomas Siegmund	**Number of Positions**	1
Project Description:	Investigate the fracture of beams built from LEGO blocks. Estabish a 3 point bend configuration. Expand the experiment to include crack prestress.		
Final Deliverables:	A report,		
Weekly Working Hours	6-9		
For Credits/Pay	For credits: 3 (# of credits) preferred For Pay: (Hourly rate): not available for pay Vontuntary: not available as voluntary position		
Desired Qualifications	ME UG student, ME 323 - required		

Project Name:	Acoustic emission from Lego Fracture	**Project ID:**	R014
Supervisor:	Professor Thomas Siegmund	**Number of Positions**	1
Project Description:	Investigate the fracture of beams built from LEGO blocks. Measure the acoustic events that occur during fracture.		
Final Deliverables:	A report,		
Weekly Working Hours	6-9		
For Credits/Pay	For credits: 3 (# of credits) preferred For Pay: (Hourly rate): not available for pay Vontuntary: not available as voluntary position		
Desired Qualifications	ME UG student, ME 323 - required		

Project Name:	Energy Storage Analytics	**Project ID:**	R015
Supervisor:	Partha P. Mukherjee	**Number of Positions**	3
Project Description:	Lithium ion (Li-ion) batteries are ubiquitous. Thermal safety and degradation characteristics of these systems are critical toward safer and high-performance batteries for electric vehicles. As part of this research, data-driven analytics of experimental and simulated performance under normal and anomalous operating conditions of Li-ion cells will be performed.		
Final Deliverables:	The final deliverable will be one end-of-semester research report (based on weekly progress presentations and updates) and one final presentation.		
Weekly Working Hours	Average: 8-10 hours		
For Credits/Pay	For credits: (# of credits) 3		
Desired Qualifications	Strong analytical skill and desire to learn new experimental and modeling & analysis tools.		

Project Name:	Laser micromachining of polymers and glasses	**Project ID:**	R016
Supervisor:	Yung C Shin	**Number of Positions**	1
Project Description:	Creating micro features on various materials is necessary for various engineering products. This research involves in creating micro channels and pockets on polymeric parts using laser ablation. Different lasers are available for this purpose depending on the optical properties of materials. This process combined with 3D printing of is to conduct an experimental study on micromachining using a CO2 laser to optimize process parameters for the best quality of microchannels formed on polymers and glasses. 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 a 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 knowledge and skills about lasers, the operation of the laser, and the characterization methods. • 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 reports describing the findings and results of the research project during the regularly scheduled meetings. A final written report is required for the final grade, which contains all the experimental results, collected microstructure data and analysis results.		
Weekly Working Hours	10		
For Credits/Pay	For credits: 3 For Pay: (Hourly rate) NA Voluntary		
Desired Qualifications	Sophomore or higher standing with the minimum GPA of 3.4		

Project Name:	Additive manufacturing of soft materials by ink-jet printing	**Project ID:**	R017
Supervisor:	Yung C Shin	**Number of Positions**	2
Project Description:	This study is to explore the additive manufacturing capabilities of novel soft materials combining different polymers, metal + polymers or ceramic + polymers, including energetic materials, using a new 3D inkjet type printer available in the supervisor's lab. The student is expected to optimize the process parameters to build successful samples using various specified materials and characterize their microstructural and mechanical properties.		
Final Deliverables:	It is expected to submit weekly or bi-weekly reports describing the findings and results of the research project during the regularly scheduled meetings. A final written report is required for the final grade, which contains all the experimental results, collected testing results and analysis results.		
Weekly Working Hours	10		
For Credits/Pay	For credits: 3 For Pay: (Hourly rate) NA Voltuntary: NA		
Desired Qualifications	Sophomore or higher standing with the minimum GPA of 3.4		

Project Name:	Laser transmission welding of glasses/polymers on metals	**Project ID:**	R018
Supervisor:	Yung C Shin	**Number of Positions**	2
Project Description:	Many mechanical and MEMS devices require joining of dissimilar materials such as joining of metals and plastics, glasses and polymers, etc. The research is to experimentally investigate the feasibility of joining fused silica or other transparent polymers on opaque polymers and metals using the technique called laser transmission welding using one of the two laser micro-welding facilities available in the supervisor's lab. The participating student needs to carry out the following tasks: 1. Literature review of related field. 2. Design experiments and carry out a systematic parametric study on the relationship between process parameters and welding quality using the available laser micro-welding system. 3. Characterize the resultant weld quality using various optical measurement techniques such as optical microscope and optical surface profiler. 4. Optimize process parameters to achieve the best quality and throughput. 5. Generate a technical report summarizing all the findings.		
Final Deliverables:	It is expected to submit weekly reports describing the findings and results of the research during the regularly scheduled meetings. A final written report is required for the final grade, which must contain literature review, design of experiments, all the experimental results, collected microstructure data and analysis results.		
Weekly Working Hours	10 (flexible in time)		
For Credits/Pay	For credits: 3 (ME298 or ME498) For Pay: (Hourly rate) NA Voluntary: N/A		
Desired Qualifications	Sophomore or higher standing with a minimum GPA of 3.4		

Project Name:	Data-driven modeling of microstructure-properties relationships for additively manufactured metal parts	**Project ID:**	R019
Supervisor:	Yung C Shin	**Number of Positions**	3
Project Description:	This study is to investigate the mechanical properties of metal alloy parts built by various additive manufacturing (AM) processes 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 in shaping complex shapes. However, one of the challenges remaining for widespread industrial use of AM is to predict/control the resultant mechanical properties. Additive manufacturing due to its inherent nature of localized heating and cooling produces heterogeneous microstructure, which affects resultant mechanical properties. Due to the number of parameters used in AM, predicting the resultant mechanical properties is very time-consuming and expensive, which remains one of the main obstacles for wide adoption in the industry. This study is to establish property-structure relationships of AM-built metal parts, which will contribute to the drastic reduction of process lead time and certification of parts. The participating student(s) is expected to establish microstructure-mechanical property relationships by collecting scattered data in the literature and then using a machine learning technique such as multilayer neural networks and deep learning methods. In addition, opportunities exist to printing actual tensile specimens using the available facilities in the supervisor's lab, conduct heat treatment, if necessary, carry out microstructure measurement, and perform mechanical testing using a universal testing machine available in the supervisor's lab.		
Final Deliverables:	It is expected to submit weekly reports describing the progress, findings and results of the research project during the regularly scheduled meetings. A final written report is required for the final grade, which shall contain a literature review, collected microstructure data, all the experimental results, and analysis results.		
Weekly Working Hours	10		
For Credits/Pay	For credits: 3 For Pay: (Hourly rate) N/A Voluntary: N/A		
Desired Qualifications	Junior or higher standing with the minimum GPA of 3.5		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Machine learning analysis of microscopy data	**Project ID:**	R020
Supervisor:	Ryan Wagner	**Number of Positions**	2
Project Description:	Effectively organizing and analyzing large data sets generated by modern microscopy instruments is a growing challenge in the fields of material discovery, biology, and semiconductor manufacturing. Machine learning approaches and other big data techniques are a powerful platform for effectively dealing with these types of data sets. This project will focus on developing and implementing effective frameworks for capturing, storing, and organizing large data sets generated from Atomic Force Microscopy (AFM) platforms. An AFM consists of a sharp nanometer scale tip that is mounted on a micrometer scale cantilever that is brought into contact with a sample surface. AFM can image surfaces at up to atomic resolution as well as capture mechanical, electrical, thermal, and chemical properties. AFM data can also be spectroscopic in nature. That is, at each pixel in an image a correlation can be measured between selected input and output parameters. The multispectral nature of AFM data makes its visualization and analysis challenging. More effective curation and exploration of large data sets are expected to be powerful tools for our group's different projects in semiconductor and materials metrology.		
Final Deliverables:	Written and/or Oral report		
Weekly Working Hours	10		
For Credits/Pay	For credits: (3) Voluntary		
Desired Qualifications	Junior or Senior status		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Design and manufacturing of an environmental test chamber	**Project ID:**	R021
Supervisor:	Ryan Wagner	**Number of Positions**	2
Project Description:	Reliability testing of microelectronic systems is often done at elevated temperature and humidity in order to shorten the time required for devices to fail. The failure rate under normal operating conditions can be extrapolated from this data. Our group has a need for an environmental chamber in which to test microelectronic devices. This chamber should consist of a heating element, humidity controller, a voltage source, and a camera to monitor the result. The goal if this project is to design, procure, build, and test such and environmental chamber.		
Final Deliverables:	Written and/or Oral report		
Weekly Working Hours	10		
For Credits/Pay	For credits: (3) Voluntary		
Desired Qualifications	Junior or Senior status		

Project Name:	Application of Machine Learning Algorithms to the Structural Analysis of aerospace systems	**Project ID:**	R022
Supervisor:	Prof. Fabio Semperlotti	**Number of Positions**	3
Project Description:	In recent years, machine learning and artificial intelligence algorithms have been rapidly expanding to the computational mechanics world. They offer the possibility to perform very challenging computations that would otherwise be beyond reach for more classical methods based on the numerical solution of differential equations. The project will involve the development and numerical implementation of machine learning algorithms to simulate the response of structural and multiphysics systems in the static and dynamic regimes. You will acquire the following knowledge: basic knowledge of neural network architectures; basic skills for the simulation of neural networks (writing and executing simple codes); basic theoretical and numerical skills for the static and dynamic analysis of structural systems.		
Final Deliverables:	Final report summarizing the models developed and the numerical results obtained. Original results of sufficient impact will be expanded in a technical publications (either conference or journal).		
Weekly Working Hours	Approximately 12 hrs per week		
For Credits/Pay	For credits: 3		
Desired Qualifications	Juniors and seniors. Interest in solid mechanics and dynamics. Helpful skills: Matlab, Python, Finite Elements.		

Project Name:	Design, simulations, and experimental validation of elastic metamaterials for the control of structural vibrations.	**Project ID:**	R023
Supervisor:	Prof. Fabio Semperlotti	**Number of Positions**	3
Project Description:	Elastic metamaterials are a class of composite materials that can achieve very unconventional mechanical and dynamic properties including, as an example, negative Poisson's ratios and cloaking. The project will involve the design and numerical simulation of composite metamaterials to achieve efficient passive control of structural vibrations. The successfully identified material systems will be built by additive manufacturing and tested in the laboratory. You will acquire the following knowledge: basic understanding of the theory of periodic composite materials; basic skills in numerical dynamic simulations of materials and structures; basic laboratory skills to prepare test samples and to test the dynamic response of materials (laser vibrometry, digital image correlation, shaker and piezoelectric transducers).		
Final Deliverables:	Final report summarizing the models developed and the numerical results obtained. Original results of sufficient impact will be expanded in a technical publications (either conference or journal).		
Weekly Working Hours	Approximately 12 hrs per week		
For Credits/Pay	For credits: 3		
Desired Qualifications	Juniors and seniors. Interest in solid mechanics and dynamics. Helpful skills: Matlab, Finite Elements.		

Project Name:	Development of structural health monitoring techniques for nanoengineered materials.	**Project ID:**	R024
Supervisor:	Prof. Fabio Semperlotti	**Number of Positions**	2
Project Description:	Structural health monitoring is a field of mechanics dedicated to the development of real-time inspection techniques to identify the possible development of structural damage in in-service structures. Self-sensing materials, such as nanoenegineered composites, allow tracking and detecting damage by monitoring their electrical response. The project will involve the development of remote sensing techniques to monitor the status (that is the possible development of cracks and structural damage) in nanoengineered composites. You will acquire the following knowledge: basic understanding of nanoengineered composites and structural health monitoring; basic skills in machine learning to develop sensing techniques; basic laboratory skills to fabricate nanoengineered composites and test them via electrical probing.		
Final Deliverables:	Final report summarizing the models developed and the numerical results obtained. Original results of sufficient impact will be expanded in a technical publications (either conference or journal).		
Weekly Working Hours	Approximately 12 hrs per week		
For Credits/Pay	For credits: 3		
Desired Qualifications	Juniors and seniors. Interest in solid mechanics and dynamics. Helpful skills: Matlab, Finite Elements.		

Project Name:	Development of quantum elastic metamaterials for analog computers.	**Project ID:**	R025
Supervisor:	Prof. Fabio Semperlotti	**Number of Positions**	2
Project Description:	Elastic metamaterials are a class of composite heterogenous materials that uses a very elaborate combination of materials and geometric designs to control the propagation of sound and elastic waves in ways not possible in regular materials. Metamaterials provide a revolutionary platform to develop the next generation of multifunctional materials for a variety of applications including, but not limited to, vibrations and sound control, acoustic cloaking, and even analog computers. The project will involve the design and numerical simulation of elastic metamaterials starting from fundamental principles. The final candidate designs will be fabricated via 3D printing and tested in the lab. This project is highly interdisciplinary and will be a great fit for students passionate about mechanics, condensed matter and quantum physcis, and applied mathematics. You will acquire the following knowledge: basic understanding of the theory of metamaterials; basic skills in numerical dynamic simulations of materials and structures; basic concept of quantum mechanics applied materials.		
Final Deliverables:	Final report summarizing the models developed and the numerical results obtained. Original results of sufficient impact will be expanded in a technical publications (either conference or journal).		
Weekly Working Hours	Approximately 12 hrs per week		
For Credits/Pay	For credits: 3		
Desired Qualifications	Juniors and seniors. Interest in solid mechanics, dynamics, physics. Helpful skills: Matlab, Finite Elements.		

Project Name:	Testing Perception of Soft Haptic Displays	**Project ID:**	R026
Supervisor:	Prof. Laura Blumenschein	**Number of Positions**	1
Project Description:	Construction and testing of a display to render haptic (sense of touch) forces to a human as they interact with the display. This project will involve working with soft, pneumatic actuators and mechatronic control systems, and helping with human subjects testing to understand the underlying perception of the devices. Displays will be designed to allow for communication of robot intent during human robot interaction.		
Final Deliverables:	Soft actuator perception experiments		
Weekly Working Hours	10 hours per week		
For Credits/Pay	For credits: (3)		
Desired Qualifications	Some previous experience with electronics and Arduino or similar systems		

Project Name:	Materials Testing in Soft Robots	**Project ID:**	R027
Supervisor:	Prof. Laura Blumenschein	**Number of Positions**	1 to 2
Project Description:	Testing how material properties affect the ability of soft growing robots (vinerobots.org) to move by growing. Will be continuing a previous project with an experimental setup. Project will primarily consist of manufacturing growing robots with new materials, data collection, and analysis.		
Final Deliverables:	Data set for growth based on material composition		
Weekly Working Hours	10 hours per week		
For Credits/Pay	For credits: (3)		
Desired Qualifications	Matrix algebra and MatLab proficiency, Ardiuno or electronics experience preferred		

Project Name:	Automatic Manufacturing for Soft Robots	**Project ID:**	R028
Supervisor:	Prof. Laura Blumenschein	**Number of Positions**	1 to 2
Project Description:	Designing a system to accurately translate soft robot designs into manufactured prototypes. Current prototypes are built by hand and take significant skill to reproduce accurately. Project would involve modifying 3D printers and other off the shelf manufacturing kits to construct new tools for soft robotic systems.		
Final Deliverables:	Design for a soft robot manufacturing system		
Weekly Working Hours	10 hours per week		
For Credits/Pay	For credits: (3)		
Desired Qualifications	Ardiuno and electronics experience. CAD software proficiency. Previous experience in actuators/machine design		

Project Name:	Hydrogen for Clean Power and Propulsion	**Project ID:**	R029
Supervisor:	Veeraraghava Raju Hasti	**Number of Positions**	2
Project Description:	The environmental regulations are becoming more stringent to reduce the emissions from fossil fuel combustion (Nitrogen oxides (NOx), CO_2, soot and particulate matter, etc.,). Hydrogen and Hydrogen enriched natural gas combustion are explored for power generation to lower these emissions. Flame stability is a major issue under lean burning conditions. This study aims to understand the effect of hydrogen on flame stability at engine-relevant conditions using computer simulations.		
Final Deliverables:	Project Report		
Weekly Working Hours	Student choice		
For Credits/Pay	For credits: 3 credit hours Or Voluntary (Student choice)		
Desired Qualifications	Thermodynamics, Fluid Mechanics, Heat Transfer, Combustion, Applied Mathematics, and Python / Matlab Programming.		

Project Name:	Analysis of Rotating Detonation Engine Combustor	**Project ID:**	R030
Supervisor:	Veeraraghava Raju Hasti	**Number of Positions**	2
Project Description:	Climate change and global warming caused by the various sources of emissions and depletion of fossil fuels are major challenges today. These challenges led to the many research and development efforts towards environmentally friendly advanced engines for power generation and propulsion in the recent decades. Rotating detonation engine offers several advantages – higher performance and compact engine architecture. In a rotating detonation engine, the continuous mode of detonation is achieved by injecting the fuel and air in an annulus combustion chamber around the cylindrical core and the resulting detonative wave propagates in the circumferential direction. This project aims to understand the flow structure and detonation wave dynamics using computer simulations.		
Final Deliverables:	Project Report		
Weekly Working Hours	Student choice		
For Credits/Pay	For credits: 3 credit hours Or Voluntary (Student choice)		
Desired Qualifications	Thermodynamics, Fluid Mechanics, Heat Transfer, Combustion, Applied Mathematics, and Python / Matlab Programming.		

Project Name:	Renewable energy forecasting using artificial intelligence	**Project ID:**	R031
Supervisor:	Veeraraghava Raju Hasti	**Number of Positions**	2
Project Description:	Achieving a decarbonized economy requires the maximum utilization of the renewable energy sources like solar and wind. One of the main drawbacks of solar and wind energy is the intermittent nature of production because of dependency on weather conditions. These intermittent sources are integrated into the grid along with energy storage, and fossil fuel-based sources to meet the demand. Hence, an accurate method of forecasting solar and wind energy is required to make informed decisions about these intermittent sources for smart electrical grid management to ensure grid reliability. This project aims to develop machine learning models for forecasting the solar and wind energy generation based on the given comprehensive list of weather parameters. Evaluate different machine learning techniques for short-term and long-term forecasting.		
Final Deliverables:	Project Report and Python Code		
Weekly Working Hours	Student choice		
For Credits/Pay	For credits: 3 credit hours Or Voluntary (Student choice)		
Desired Qualifications	Data Science, Machine Learning, Applied Mathematics, and Python Programming.		

Project Name:	Immersible sensors	**Project ID:**	R032
Supervisor:	Euiwon Bae	**Number of Positions**	2
Project Description:	Applied optics lab is searching for UG student who are interested in continused development of immersible photonic sensors. Project is related to umbrella project from USDA pathogen detection and we are seeking student who will do the following. -Mechanical : design a water tight ensloure that could be repeatily opened up and closed again without loosing the water proof nature. -Electrical : design a arduio based light detection system. Requirement is to be operated by coin/lithium battery so that min of 10 hrs of operation is guaranteed.		
Final Deliverables:	Ensloure protoypte (Mechanical) and sensor prototype (Electrical)		
Weekly Working Hours	5-10 hrs		
For Credits/Pay	For credits: (# of credits) 2 credits (5 hrs/week) or 3 credits (9 hrs/week) For Pay: (Hourly rate) Vontuntary		
Desired Qualifications	Experience of arduino for electrical part will be desirable		

Project Name:	Comparison of Burning Rate Measurements for Crawford Bomb, Class III Motor, and Dual Propellant Pseudo Motor	**Project ID:**	R033
Supervisor:	Steven Son – PI Tim Wagner – Graduate Research Assistant	**Number of Positions**	2
Project Description:	Small scale propellant burning rate tests in the Crawford Bomb using visual and microwave interferometry diagnostic techniques to determine burning rate. 336 total small scale experiments for a machine learning database.		
Final Deliverables:	336 Crawford Bomb Experiments “21 tests per week for 16 weeks”		
Weekly Working Hours	10		
For Credits/Pay	For credits: (# of credits) For Pay: (Hourly rate) Vontuntary		
Desired Qualifications	Experience with Oscilloscopes, high speed cameras, solid propellants, and can lift 20 lbs.		

PURDUE UNIVERSITY | Mechanical Engineering

Project-based research

Project Name:	3D video visualization	**Project ID:**	R034
Supervisor:	Song Zhang	**Number of Positions**	3
Project Description:	This project will develop software to visualize high-resolution 3D video data. Specifically, we will visualization 3D videos on a VR device (i.e., Occulus Quest 2) and a Holoraphic display.		
Final Deliverables:	The final deliverable will be software tool and user manuals for 3D video data visualization.		
Weekly Working Hours	10-12 hours		
For Credits/Pay	For credits: (# of credits) 3		
Desired Qualifications	Strong communication skills, and desire to learn. Preferrable having prior experience in C#, Python or Unity.		

PURDUE UNIVERSITY | Mechanical Engineering

Project-based research

Project Name:	3D Imaging Software Development	**Project ID:**	R035
Supervisor:	Song Zhang	**Number of Positions**	1
Project Description:	This project aims at developing a 3D imaging device that can be used by law enforcement for crime scene evidence collections. The student will closely work with a graduate student to help both software and hardware system development. Undergraduate student will help graduate students develop the GUI for the new GLSL viewer for XYZT Lab. In the meantime, undergraduate student will help to maintain the calibration and reconstrctuion software for the group. Lastly, the undergraduate student is expected to explore the registration algorithm together with graduate student.		
Final Deliverables:	• Software algorithms and result report • GUI for new GLSL viewer		
Weekly Working Hours	10-12 hours / Week		
For Credits/Pay	Based on discussion with supervisor		
Desired Qualifications	• Basic coding capabilities with C / C++ / C# • Familiar with use of Visual Studio and Github (For version control) • Had experience with simple GUI development • Strong communication skills • Capable of conducting experiments by self		

PURDUE UNIVERSITY | Mechanical Engineering

Project-based research

Project Name:	3D Imaging System Hardware Design	**Project ID:**	R036
Supervisor:	Song Zhang	**Number of Positions**	1
Project Description:	This project aims to design a 3D imaging system for crime scene evidence collection in forensic science. The undergraduate student will primary work with graduate student mentors. Undergraduate student will participate in the process of hardware system design such as modeling, fabrication, and assembly. Student will also learn 3D imaging system operation and calibration. Once students are familiar with the system, they will be involved with design of experiment and field testing.		
Final Deliverables:	• Model and fabricate the system with CAD software • Identify hardware components • Design of experiment and system testing		
Weekly Working Hours	10-12 hours / Week		
For Credits/Pay	Based on discussion with supervisor		
Desired Qualifications	• Students with experience of CAD design • Basic coding skills(at least MATLAB) • Hands-on Skills		

Project Name:	Autonomous vehicle based on 3D sensing	**Project ID:**	R037
Supervisor:	Song Zhang	**Number of Positions**	Up to 2
Project Description:	This project aims at developing a high-end 3D vision system and video processing algorithms for remote control of autonomous vehicles. The student(s) will join a team of undergraduate and graduate students.		
Final Deliverables:	• Software packages		
Weekly Working Hours	~10-12 hours / week		
For Credits/Pay	For credits: (3 credits each).		
Desired Qualifications	Prior experiences of ROS and C++ is preferred. Strong communication skills.		

Project Name:	Instrumentation of Micro-3D Printers	**Project ID:**	R038
Supervisor:	Liang Pan	**Number of Positions**	1-2
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 new operation mode that can expand print envolops by fast stitching of subprints.		
Final Deliverables:	A working microscale 3D printer, including the hardware and control software		
Weekly Working Hours	3 credit hours (10-15 hours work load per week).		
For Credits/Pay	For credits: (# of credits) For Pay: (Hourly rate) Vontuntary		
Desired Qualifications	Applicants expect to have one of the following capabilities. 1. Operation of 3D printers 2. Labview programing 3. Optical experiments		

Project Name:	Microfluid heat exchanger design optimization and testing for thermal management applications	**Project ID:**	R039
Supervisor:	Liang Pan, Justin A Weibel	**Number of Positions**	1-2
Project Description:	Heat exchangers are ubiquitously used in nearly all aerospace, automotive, and other applications where fluids are used to remove or reject heat. Miniaturizing the features inside heat exchangers to the microscale has the potential for major gain in the working efficiency and can potentially offer high peak cooling capability for high power applications, such as cooling of supercomputers or power electronics. New microscale manufacturing techniques allow the rapid protoyping of complicated microflow structures. In this project, students will work as part of a team where such features are optimized using computer-aided design algorithm to optimize multi-layer, two-fluid heat exchanger structures. The team will then fabricate and test novel microfluid heat exchangers for high-power applications.		
Final Deliverables:	Design and testing results..		
Weekly Working Hours	3 credit hours (10-15 hours work load per week).		
For Credits/Pay	For credits: (# of credits) For Pay: (Hourly rate) Vontuntary		
Desired Qualifications	Excellent performance and interest in the topics covered in ME315, with opportunities for both theoretical and experimental constirbutions to the work. Students from under-represented minorities (URM) groups are highly encouraged to apply.		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Thermal Transport Characterization in Heterogeneous Packaging	**Project ID:**	R040
Supervisor:	Amy Marconnet & Justin Weibel	**Number of Positions**	>= 1
Project Description:	High conductance interfaces are becoming critical in next-generation electronic devices, for example with the development of high-performance thermal interface materials and direct bonding techniques for monolithic heterogeneous integration. However, there are no standard tools/techniques for accurately characterizing the thermal resistance across interfaces buried within electronics packages to this particular range of thermal resistances. ASTM standard methods such as the reference bar method work well for bulk insulating materials and high thermal resistances but hit limits of accuracy at these low resistances. Conversely, thermoreflectance (TR) methods have sufficient accuracy but are limited to characterizing interfaces within nanometers to a few microns of the surface and cannot assess more deeply buried interfacial layers. Thus, a new method is needed to characterize interfaces within systems that have low resistance. Our newly devleoped metrology technique (see illustration above) can be extended to understand multi-layer systems to understand thermal interface resistances. The goal of this project would be to use computational tools (likely COMSOL) to design the system for characterizing this parameter and design the metrology platform that could be fabricated following the project.		
Final Deliverables:	Final report documenting design of thermal metrology platform with numerical validation. Presentation(s) in group group meeting and/or poster sessions.		
Weekly Working Hours	10 hr/week		
For Credits/Pay	For credits: 3 credits For Pay: TBD Vontuntary		
Desired Qualifications	ME 200 and ME 309: A- or better ME 315 recommended Comfortable coding in Matlab