The University of Arizona

Craig M. Berge Engineering

DESIGN

Day 2022

THE UNIVERSITY OF ARIZONA
COLLEGE OF ENGINEERING

Craig M. Berge Engineering Design Program

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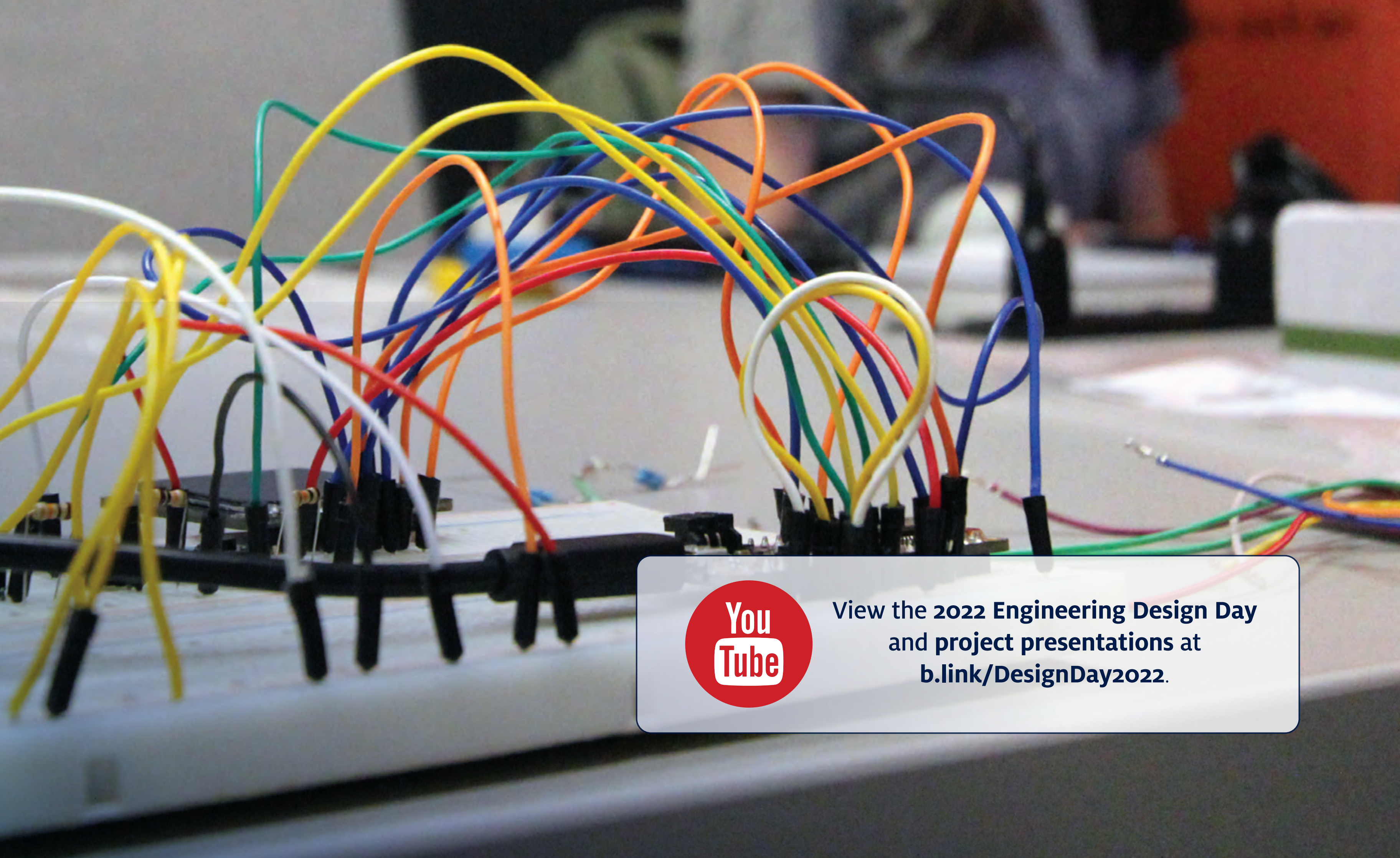
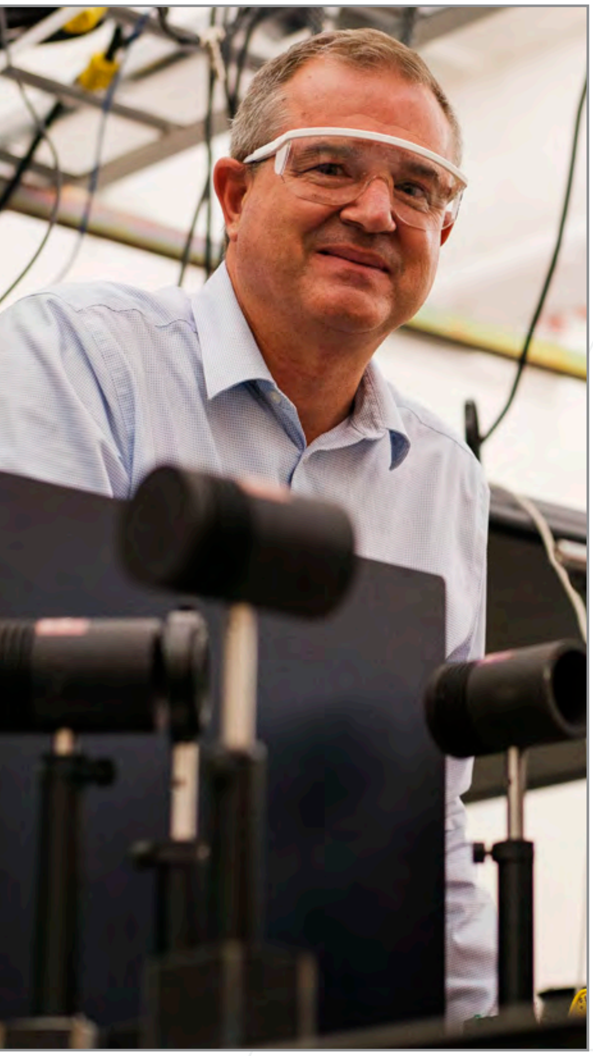


View the **2022 Engineering Design Day** and **project presentations** at **b.link/DesignDay2022**.

Welcome to 2022 Craig M. Berge
Engineering Design Day



Seniors take center stage with this pivotal Wildcat engineer event back in person.

Craig M. Berge Design Day is a story of remarkable student success and of all the ways engineers help people. With nearly 100 incredible capstone projects, 100 seasoned industry judges and $46,250 in prize money, we have much for which to be thankful this year, including being back to presenting Design Day publicly.

Something for Everyone

Students collaborated in labs and workshops on lean, green and smart machines, systems to grow crops in space and robots for greenhouses on Earth. They developed ways to make air travel safer, recycle lithium batteries, generate windmill power, and provide clean water on the Navajo Nation. Teams prototyped tools that help surgeons correct flatfoot, hearing impaired people follow group conversations, individuals using walkers lift heavy objects, and zoo workers disperse elephant snacks, to name just a few.

Our students are thrilled to tell you about these fantastic projects, a year in the making. Not only are the designs a testament to the technical agility and creativity of our students and mentors, but they also show why the college's graduates are highly sought after in industry and government.

Please join us on campus for the Design Day Awards ceremony at 4 p.m. on May 2 to recognize the accomplishments of our seniors. And, if you miss anything, you can still learn about the projects online in the students' presentation videos, which will be available following the awards ceremony.

Thank You for Your Support

Design Day and the Interdisciplinary Capstone Course are part of a lineup of competitions, maker fests, major-specific design courses, entrepreneurial and business instruction, and industry and community projects in the Craig M. Berge Engineering Design Program. The program immerses undergraduates at all levels in real-world experiences that integrate design, manufacturing and commercialization.

None of it would be possible without all the hard work behind the scenes. We are grateful to the donors, program mentors, university and industry partners, sponsors, judges, faculty, staff, and alumni who help make the program and event into a highly successful enterprise.

A special thank you to Nancy Berge and her family for their generosity, and to Larry Head, director of the Craig M. Berge Engineering Design Program, for his dedication to an unparalleled experiential learning program and design curriculum in higher education.

Bear Down, and support our Wildcat engineers!

David W. Hahn
Craig M. Berge Dean, College of Engineering

2022 FAST FACTS

97
DESIGN TEAMS

100+
TECHNICAL JUDGES

$46,250
IN PRIZES

500+
STUDENTS

75
CORPORATE & UA SPONSORS

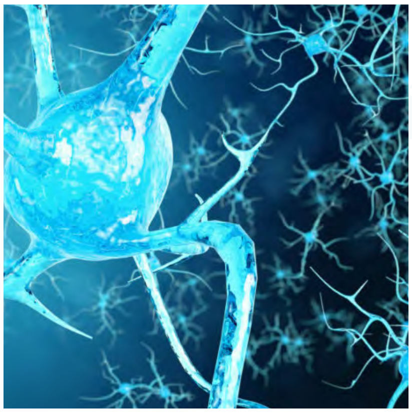
21
BIOMEDICAL PROJECTS

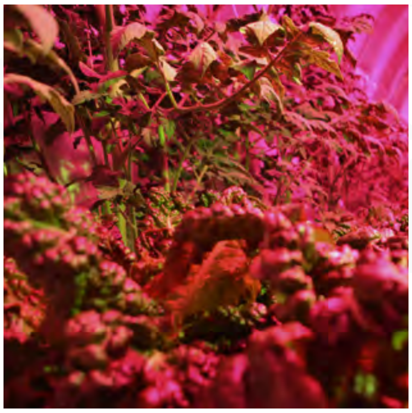
12
SPACE-RELATED PROJECTS

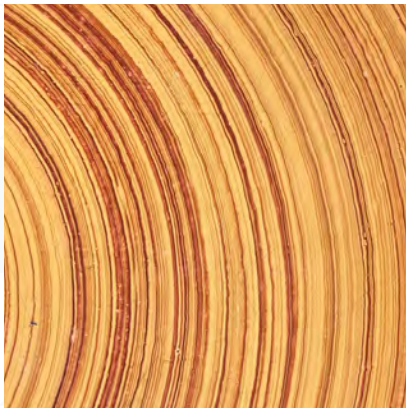
18
ENERGY, ENVIRONMENTAL & MINING PROJECTS

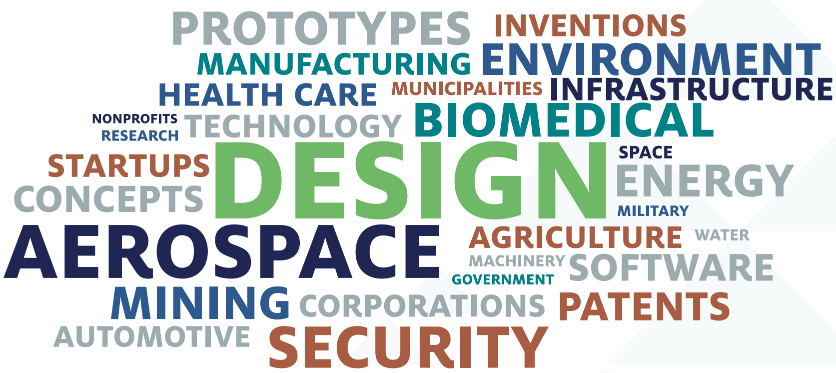
> “Pulling in different, fresh perspectives from students has been really valuable for us.”
>
> *Sponsor advisor* **TOM TRUEBLOOD,** *PING Golf Analysis and Testing Manager*

PROJECTS

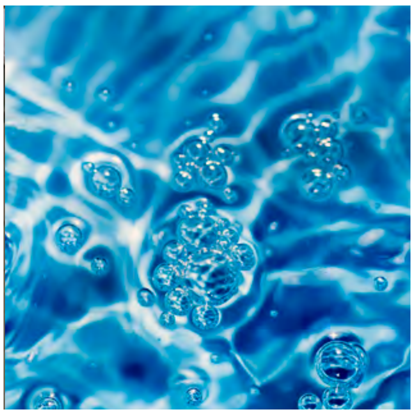


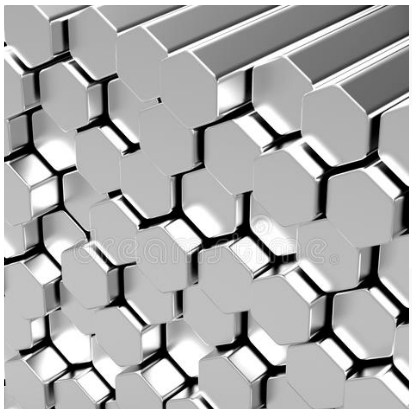


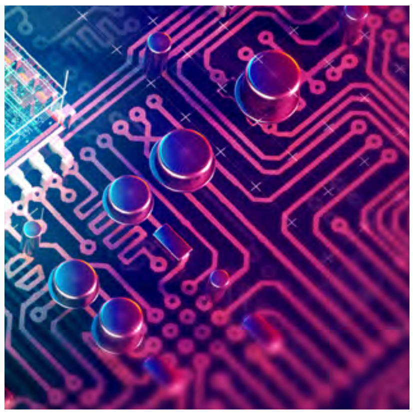




PROTOTYPES
INVENTIONS
MANUFACTURING
ENVIRONMENT
HEALTH CARE
MUNICIPALITIES
INFRASTRUCTURE
NONPROFITS
RESEARCH
TECHNOLOGY
BIOMEDICAL
STARTUPS
CONCEPTS
DESIGN
SPACE
ENERGY
MILITARY
AEROSPACE
AGRICULTURE
WATER
MACHINERY
GOVERNMENT
SOFTWARE
MINING
CORPORATIONS
PATENTS
AUTOMOTIVE
SECURITY







> “I think what’s really cool about our team is how quickly we’ve been able to come together and focus on a specific goal, and kind of track that problem from different angles.

MICHAEL GAINES,
industrial engineering student

AWARDS

Craig M. Berge Dean's Award for **MOST OUTSTANDING PROJECT**

($7,500)

This award recognizes the project that embodies the best attributes of engineering design and the engineering profession. The winning project shall have an outstanding design approach and implementation, excellent system modeling and/or analysis that support the design, comprehensive system testing that verifies system requirements, and a superior presentation of results to Design Day judges. Members of the winning team shall present themselves professionally and clearly demonstrate engineering knowledge of the design. The winning project shall clearly be the best project at Design Day.

Raytheon Award for **BEST OVERALL DESIGN**

($5,000)

While several designs may meet the judging criteria, this award is given to the design that does so the most effectively. The project that receives this award excels in many ways. The design is well thought out and its implementation is of high quality. It accomplishes all key design requirements and is supported by rigorous analysis and testing. Its poster and presentation are professional and easy to understand.

Bly Family Award for **INNOVATION IN ENERGY PRODUCTION, SUPPLY OR USE**

(1st prize - $2,000; 2nd prize - $1,000)

This award recognizes the best project related to sustainable, cost-effective and environmentally friendly energy production, distribution or use. Winning projects could focus on developing new energy sources, reducing energy costs, improving efficiency of energy distribution or use, or adapting existing distribution methods to better integrate new energy sources.

Ball Aerospace Award for **BEST SYSTEM SOFTWARE DESIGN**

($2,500)

Software has become a critical part of the operation, management and control of complex systems comprising mechanical, electrical, biomechanical and other subsystems. This award recognizes the best use of software in the process of designing systems for operation, management, control and usability. Teams will be judged on the reliability, robustness, maintainability, reusability, originality and testability of software embedded in their designs.

ACSS, an L3Harris and Thales Joint Venture Award for **MOST ROBUST SYSTEMS ENGINEERING**

($2,500)

The systems engineering perspective is based on systems thinking. When a system is considered as a combination of elements, systems thinking acknowledges the primacy of both the whole and the relation of the system elements to the whole. This award goes to the team that most robustly addresses all aspects of the project from the systems perspective.

RBC Sargent Aerospace & Defense **VOLTAIRE DESIGN** Award

($2,500)

The French philosopher Voltaire is credited with the saying "Le mieux est l'ennemi du bien," which means "the best is the enemy of the good." Similarly, Leonardo da Vinci is credited with the saying "Simplicity is the ultimate sophistication." This award recognizes the design team that best emulates these ideals and resists the temptation to overly complicate the design to yield a clean, simple, elegant, lowest-cost design that simply works well.

II-VI Aerospace & Defense Award for **BEST OPTICAL SYSTEMS DESIGN**

($1,500)

This award recognizes the most innovative use of optoelectronics and optomechanics in a design and is given to the team that demonstrates the most thorough approach to the design and engineering of its optical system. This award recognizes complete understanding of the optical design, system requirements, tolerance analysis and optical component usage. Important criteria are integration of optics into the overall system, novel use of optical components, creative use of commercial off-the-shelf items, verification of optical components, meeting system requirements, use of standard optical design software, and manufacturability of optical design and components.

Rincon Research Award for **BEST PRESENTATION**

($1,500)

This award reflects the quality of the overall verbal and poster presentations. Verbal presentations should efficiently describe the overall problem and the specifics of how the team created a solution. Answers to questions should be direct and demonstrate mastery of the project. Presenters should speak in clear and easily audible voices, making good eye contact with the judging pod. The poster board should be visually interesting and graphically well organized to tell a standalone story of the project.

Cliff Andressen Award for **DESIGN ABOVE AND BEYOND**

($1,500)

This award recognizes a design solution that goes above and beyond the project design requirements and produces results that may be useful for other products and applications. Solutions that are sufficiently innovative for a potential patent application and that may form the basis of a new startup will be given special consideration in the selection process.

Roche Tissue Diagnostics Award for **MOST INNOVATIVE ENGINEERING DESIGN**

($1,500)

Innovation may include the novel use of existing components or the creation of entirely new components to meet customer requirements. The most innovative design will not only be a creative solution, but also an effective and well-implemented solution. This award recognizes the team that has created or made use of components in the most innovative way, demonstrated excellence in innovative design, or both.

Frank L. Broyles Award for **BEST UAS DESIGN**

(1st prize - $1,000; 2nd prize - $250)

This award recognizes the unmanned aircraft systems project with the highest quality of design and construction, and which achieved or made a strong effort to achieve the sponsor objectives.

W.L. Gore and Associates Award for **LIFELONG INNOVATION**

($1,250)

This award honors a student team whose project has improved or enhanced the quality of life for individuals. It recognizes the improved standard of health, comfort, environment, community and happiness experienced by an individual or group. Projects are judged on the ability to promote the well-being of humans through togetherness and the practicality of the implementation. Teams should be able to effectively communicate their design and how it will improve lives.

Mark Brazier Award for **BEST BIOMEDICAL SYSTEM DESIGN**

($1,000)

Biomedical engineering advances knowledge in engineering, biology and medicine. It also improves human health through interdisciplinary work that integrates the engineering sciences with biomedical sciences and clinical practice. This award recognizes the team that has demonstrated excellence and innovation in biomedical engineering design. It recognizes out-of-the-box thinking that pushes boundaries and includes hands-on approaches to creative solutions. Projects are judged on the elegance, creativity and implementation of the technical solutions. Teams should be able to effectively communicate their design and creative processes.

Technical Documentation Consultants of Arizona Award for **BEST DESIGN DOCUMENTATION**

($1,000)

Successful implementation of any innovative design requires that all members of the design and production team communicate effectively. Design intent must be communicated using design documentation with a clear map for others to reproduce the design. The mechanical portion of the design is evaluated on the use of drawings with geometric dimensioning and tolerancing, solids models, illustrations and presentations that can be used to manufacture and inspect design hardware. Software and other systems are evaluated on the use of documentation that clearly and fully describes the system and illustrates the approach to testing.

TRAX International Award for **BEST IMPLEMENTATION OF AGILE METHODOLOGY**

($1,000)

This award recognizes the team that best executes project design using a flexible and incremental approach. Final project outcome is achieved through several test and evaluation iterations in collaboration with the customer. The project team should continuously review and assess results, and quickly adapt to any changes or problems encountered.

Sharon ONeal Award for **BEST INTEGRATION, VERIFICATION & VALIDATION**

($1,000)

Integration, Verification and Validation (IV&V) activities in the engineering lifecycle are crucial to delivering products that meet user requirements and are free from design and implementation flaws. This award recognizes the project that best documents and demonstrates a comprehensive mapping and execution of IV&V test plans, processes, procedures and results to the user requirements and product Concept of Operations (ConOps). To be eligible for consideration of this award, projects must include at least three types of subsystems, such as software, electronic, mechanical or optical. Comprehensive documentation of all integration and verification test activities must be included with the award nomination. This documentation includes all project requirements, test plans, procedures, and documented/verified results, signed off by the project sponsor or designee.

The Mensch Foundation Award for **BEST USE OF EMBEDDED INTELLIGENCE**

($1,000)

This award recognizes the team that best integrates embedded intelligence into a potential commercial product. The award will be granted to a student team that builds a smart connected prototype that may have a commercial market. Embedded intelligence is the ability of a product to sense, process, communicate, and actuate (SPCA) using understanding of both itself and others, and for the benefit of many. Preference will be given to designs with SPCA capabilities that can demonstrably surpass human abilities to perform the same function.

Garmin Award for **BEST USE OF WIRELESS TECHNOLOGY**

($1,000)

Wireless technology is ever present in today's world. It allows products to be used in a wide variety of applications, from streaming movies on the couch to receiving pictures from Mars. With so many wireless technology options available, it's critical for engineers to understand the tradeoffs each provide, and how they might be used to expand the capabilities of a design. This award will be given to the team that demonstrates the best use of a wireless technology in their design.

Honeywell Award for **EXCELLENCE IN AEROSPACE ELECTRONIC SYSTEM DESIGN**

($1,000)

This award recognizes excellence in overall system design in a project with an aerospace emphasis. Verbal and written presentations should effectively describe the overall system and the specifics of how the team implemented its design project. The presentation must include representative data that demonstrate how the system was thoroughly tested. Answers to questions should be direct and demonstrate a high level of team knowledge about the details of the electronic system for the project. The presentation should demonstrate how all members have contributed to the project to exhibit core values of teamwork and professionalism.

Honeywell Award for **EXCELLENCE IN AEROSPACE MECHANICAL SYSTEM DESIGN**

($1,000)

This award recognizes excellence in overall mechanical system design in a project with an aerospace emphasis. Verbal and written presentations should effectively describe the overall system and the specifics of how the team implemented its design project. The presentation must include representative data that demonstrate how requirements were analyzed, documented, designed against and tested. Answers to questions should be direct and demonstrate a high level of team knowledge about the details of the mechanical system. The presentation should demonstrate how all members contributed to the project to exhibit core values of teamwork and professionalism.

Steve Larimore Award for **PERSEVERANCE & RECOVERY**

($1,000)

Issues and roadblocks always occur during the engineering design process. Although they can cause panic and distress, they also represent opportunities to learn and often lead to designs that would otherwise be impossible to conceive. This award recognizes a team's ability to learn and overcome obstacles. The award is judged based on the ingenuity of solutions and the features in the final design that contribute to recovery from setbacks.

SciTech Institute Award for **BEST ENGINEERING ANALYSIS**

($750)

This award recognizes the team with the strongest strategy, implementation and documentation of analyses supporting its design. Analyses vary from project to project, but may include market research and analysis, analysis of prior solutions, trade studies that justify the final design versus alternatives, system modeling to demonstrate the final design should perform as desired, analysis of potential reasons for failure and a mitigation plan, and economic or other analysis of the benefits of the final design in its intended application. Criteria for judging include the completeness of the project analysis based on the above categories, thoroughness of the analyses, application of sound engineering principles and practice, a demonstrated understanding of any tools or models used, reasonableness of all assumptions, and the quality of analyses documentation.

Phoenix Analysis & Design Technologies Award for **BEST USE OF PROTOTYPING**

($750)

This award goes to the team that best uses a physical prototype model to understand and study the fit, form and function of the device or system designed. Teams are judged on the appropriateness of the prototyping technology used, how effectively prototyping is used to improve design, and how effectively the use of prototyping is communicated. Prototypes can be made using rapid fabrication technology or traditional manufacturing, or can be hand built.

II-VI Aerospace & Defense **FISH OUT OF WATER** Award

($750)

The Fish Out of Water award congratulates students for successfully accomplishing tasks that were not in their realms of expertise. Senior design projects require skills from many disciplines, and students must sometimes learn a new subject or skill in an area outside of their major to help the team succeed. A student who not only learns this new subject or skill, but also uses it to effectively help the team thrive, shows dedication and initiative – traits that are invaluable in an engineering career.

AZ Technica Award for **MANUFACTURING READINESS**

($500)

This award is given to a team whose system goes beyond sponsor requirements and best considers usability and manufacturing readiness. Teams will be judged on whether they did the following: considered alternative designs and selected the best choice; met or exceeded sponsor requirements; considered producibility, ease of assembly and cost; considered reliability and maintainability in both prototyping and build phases; considered user operation and included operator instructions; and included a complete design technical data package.

AZ Technica Award for **SUSTAINABLE MANUFACTURING INNOVATION**

($500)

This award is given to the team whose design incorporates the most innovative manufacturing method to address reduced carbon emissions. Projects could include introducing a new technique for manufacturing or an innovative use of an existing technique that reduces a product's cost and carbon footprint while increasing quality.

Dataforth Corporation Award for **BEST DESIGN USING A DATA ACQUISITION AND CONTROL SYSTEM**

($500)

This award recognizes the team that best implements a modern data acquisition and control system. Recognition is given for a system that collects data to characterize and optimize project performance. Ideally, the same data acquisition system is used to perform feedback and control operations.

L3 Latitude Engineering Award for **BEST PHYSICAL IMPLEMENTATION OF ANALYTICALLY DRIVEN DESIGN**

($500)

Some engineering problems are straightforward: Optimal solutions are found through the application of engineering best practices. Sometimes, however, the best design choices are not obvious, and only reveal themselves after a thorough analysis of the underlying physical principles. This award recognizes a design that could only have been arrived at after careful study and creative application of physics.

Simpson Family Award for **BEST SIMULATION AND MODELING**

($500)

This award recognizes the project that makes the best use of computer-based simulation or modeling. The simulation may be the project itself, or a design tool used to model the performance of the project design. Criteria for this award is based on scope of the simulation, the fidelity of the simulation compared to real-world performance, and the engineering judgement exercised in determining the complexity of the model.

Ergo Dave Award for **BEST USE OF HUMAN FACTORS ENGINEERING**

($500)

This award recognizes the team that makes the best iterative use of Human Factors and Ergonomics (HFE) design principles: understand, design, evaluate. The winning team will provide evidence that members collected data, understood both tasks and users, and showed significant reduction of fatigue and workload to users.

Honeywell Award for **TEAM LEADERSHIP**

(two individuals at $250 each)

This award recognizes students who best exemplify teamwork skills, including working cooperatively with others to produce high-quality work, taking initiative, supporting and respecting the opinions of fellow team members, giving and receiving feedback, demonstrating effective leadership, keeping their teams focused, and elevating fellow team members' work. Nominees for this award are selected by their teammates.

FROM THE DESK OF

NANCY BERGE

Dear students,

Thank you to everyone who has participated in this wonderful event, the Craig M. Berge Design Day which bears our family name. My family and I are delighted to see and learn about your design projects. They are truly outstanding.

Much of my husband's life and engineering career was all about designing. As a student, he built and designed his dragster. Later in life, as a mechanical engineer, he worked for a company that paid for his education. The company loaned him to the U.S. Navy to design the starter for a jet airplane named the Intruder. That plane is on aircraft carriers to this day. Knowing that the Navy is still using something he created is truly remarkable.

My husband would expect remarkable things from each of you, too. He would be so proud of your creativity and all you have accomplished.

In my husband's memory, I am honored to support the Craig M. Berge Engineering Design Program and these student experiences that move you toward the next chapters in your lives and careers.

All the Best,

Nancy Berge

"It's a win-win deal for the students and the company. You look at the number of companies that are involved, and obviously, we're not the only guys that think that."

sponsor advisor **GEORGE WIESE**, *founder of Nature's Cooling Solutions*

PROJECT DESCRIPTIONS

Let's Boil a Computer

Team 22001

Microsoft

PROJECT GOAL

Create a test vessel for high-efficiency two-phase immersion cooling of servers. This system maximizes cooling while minimizing energy usage and environmental effects.

Two-phase immersion cooling is an efficient and cost-effective way to cool data centers. Additionally, this method is far less likely to negatively affect the environment because it uses significantly less water and electricity than conventional cooling. Electronics are submerged in a non-conductive fluid so there is no damage to components. The temperature of the fluid remains near its boiling point to create a saturated gas-liquid state in the tank. Microsoft Corp. has started to implement this technology but needs a small-scale tank in which to perform tests.

The students designed, developed, integrated and tested a novel tank design for system optimization.

The design consists of a quartz tank and acrylic lid, sealed with a laser-cut rubber gasket. Fluorinert, created by 3M, is the fluid in which the computer is submerged. As the computer heats up, the Flourinert begins to evaporate and increases the internal pressure of the tank. Sensors inside the tank monitor the temperature, pressure and level of Fluorinert. This data, along with the increased tank pressure helps control a cooling loop that condenses gaseous Fluorinert and maintains a temperature at or below boiling, which is highly efficient for the processor.

TEAM MEMBERS

Kevin Antony Gomez, *Electrical & Computer Engineering*
Rose Bandrowski, *Systems Engineering*
Quinn Choffin, *Mechanical Engineering*
Jennifer Espersen, *Mechanical Engineering*
Haseeb Sarwar Irfan, *Electrical & Computer Engineering*
Connor McCreary, *Electrical & Computer Engineering*

COLLEGE MENTOR

Bob Messenger

PROJECT ADVISOR

Nicholas Keehn

Smart Glove v2 Electronic Sensor Array

Team 22002

Idea2Success.BIZ
COLLABORATORY

PROJECT GOAL

Integrate novel electronic sensor arrays into smart gloves to display the weight of objects and work performed, with the goal of reducing repetitive stress injuries in the workplace.

Having the ability to measure and display the weight of lifted objects, along with work performed, provides valuable information to employees and companies. Workers can control how much work they are performing when carrying or lifting objects and use the data to limit excessive exertion, reducing the risk of repetitive stress injuries.

This team designed, developed, integrated and tested a novel flexible sensor array that measures weight lifted and work performed.

The Smart Glove uses an inductive sensor to measure the weight of an object held by the user, instantaneously and over time. This weight is measured at a frequency of 20 Hz and subsequently summed to display a total quantified weight in addition to the time under tension, to within 5% accuracy. The Smart Glove is intended for use in warehouses and gyms.

TEAM MEMBERS

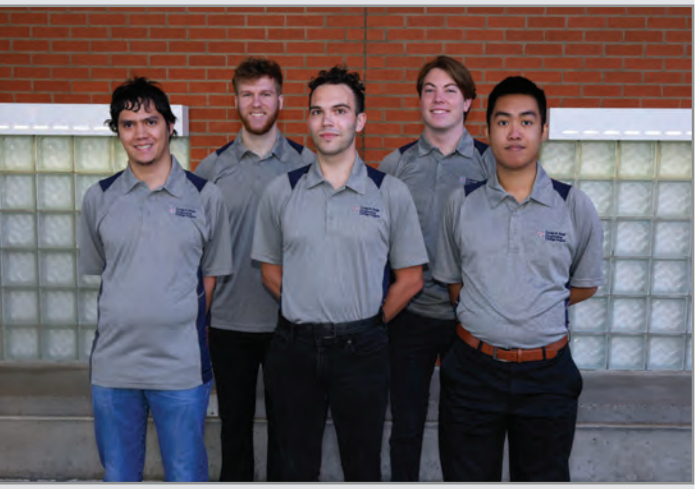
Dominic Maxwell Holsinger, *Electrical & Computer Engineering*
Fitz Lee, *Engineering Management*
Michelle Loustaunau, *Electrical & Computer Engineering*
Roberto Peralta, *Mechanical Engineering*
Armand Santilli, *Biomedical Engineering*

COLLEGE MENTOR

Bob Messenger

PROJECT ADVISOR

Paul Efron



Smart Gloves v3 Hydraulic

Team 22003

Idea2Success.BIZ COLLABORATORY

PROJECT GOAL

Using an integrated wearable hydraulic pressure system, design a smart glove that measures and displays the amount of weight lifted and work performed by an individual.

The Hydraulic Smart Glove provides an interface for measuring the forces and work performed during everyday physical activities. Real-time data allows users to track the amount of weight lifted and work performed during physical activity. With this wearable device, fitness fanatics, construction workers and physical therapists alike can work safer and smarter.

This team created a system that uses hydraulic tubing, hydraulic fluid, and a manifold, all integrated into the smart glove with a pressure transducer measuring the pressure applied to the tubing.

The students developed software with calibrated curves to calculate the weight lifted and the work performed based on the pressure inside the tubing. Sensor data is collected by an Arduino Nano microcontroller. Key data is displayed using a graphical user interface (GUI) on an LED display. The user interacts with the system and GUI via buttons for calibration, setting the time, changing units and altering brightness.

TEAM MEMBERS

Cole Bauer, *Systems Engineering*
Brandon Bui, *Electrical & Computer Engineering*
Thomas Kulaga, *Mechanical Engineering*
Conner James Pierce, *Electrical & Computer Engineering*
Cory Saunders, *Biomedical Engineering*

COLLEGE MENTOR

Bob Messenger

PROJECT ADVISOR

Paul Efron

ELECTRONIC SPEED CONTROLLER FOR RESEARCHERS

Team 22004

BFS

PROJECT GOAL

Design and build an ESC for brushless DC motors that reports controller and motor telemetry through the CAN bus protocol.

Electronic Speed Controllers (ESCs) are used to control the operation of electric motors in Unmanned Aircraft Systems (UASs). Research institutions require ESCs that can collect operating telemetry from the controller and motor when developing UAS technologies. Readily available ESCs do not have these functionalities and are limited to operating a narrow range of motor sizes, making them unusable in research applications.

The team built a functional ESC that operates over a wide range of motors and collects the required data within 1% accuracy.

The ESC uses a Teensy 4.1 microcontroller as its main processing unit. Speed instructions are transmitted to the Teensy 4.1 from an external flight computer, which are then processed to control the motor's RPM. The Teensy 4.1 also collects the temperature and motor's RPMs, current draw and voltage. All telemetry data is transmitted to the flight computer using the CAN bus protocol. The ESC is packaged in an aluminum enclosure with active cooling to safely operate motors ranging from 10V to 50V, with a maximum continuous current draw of 120A.

TEAM MEMBERS

Jassem Al-Fouzan, *Industrial Engineering*
Rafael Candelas, *Electrical & Computer Engineering*
Jacob Dukelow, *Mechanical Engineering*
Merrick Martin, *Mechanical Engineering*
Fausto Alexander Sanchez, *Electrical & Computer Engineering*

COLLEGE MENTOR

Pat Caldwell

PROJECT ADVISOR

Brian Taylor

Folding Portable Walker With Integrated Lifting Function (Tonee Lift II)

Team 22005

PROJECT GOAL

Develop a walker that can lift objects from the ground to a height accessible to the user.

The Tonee Lift walker helps patients with spinal fusion and other low-mobility conditions lift objects from the floor, greatly increasing their independence. In addition to the lifting functionality, the walker has a sweeper arm for pushing objects from the floor onto the lifting plate.

This team was tasked with turning earlier prototypes and models of the Tonee Lift walker into a more durable, user-friendly and market-ready product. The design requirements presented several engineering challenges: improving walker center of gravity, overcoming friction in the lift with a 25-pound load, making the lifting plate foldable, and controlling the descending speed of the lift with a 25-pound load.

The students built the Tonee Lift II walker out of aluminum, including 1-inch tubing and sheet metal to meet a weight requirement of less than 40 pounds and designed a component that lifts a maximum 25-pound object from the floor to 3 feet. The team incorporated bearings and a gearbox with a clutch. To prevent beyond-range motion, the design includes switches at the minimum or maximum position to open the circuit and cut the power to the motor. A current limit circuit cuts motor power when the load on the lift is too heavy. And, an off-the-shelf product indicates battery charge.

TEAM MEMBERS

Evan John Braband, *Mechanical Engineering*
Julia Kathleen Burling, *Mechanical Engineering*
Ethan Joseph Hufault, *Mechanical Engineering*
William Alexander Reuter, *Industrial Engineering*
Lexie Marie Solsky, *Mechanical Engineering*
Cris Alfred Soria-Galvarro, *Electrical & Computer Engineering*

COLLEGE MENTOR

Steve Larimore

PROJECT ADVISOR

Gaby Doyle

Slide Label Applicator for Simplified Handling

Team 22006

PROJECT GOAL

With minimal user intervention, apply labels appropriately onto microscope slides containing tissue samples.

Lab technicians apply labels to microscope slides after applying tissue samples. The process of printing the label, peeling it off of the backing paper, then placing it on the designated area of the slide while maintaining the integrity of the tissue sample can be repetitive and tedious.

Thus, the goal of this project was to create a prototype that will increase slide labeling productivity and decrease risks of impairments associated with repetive injury.

Designing a Slide Label Applicator for Simplified Handling (SLASH) presented several engineering challenges: peeling labels with different adhesive strengths from the backing paper, positioning the label in the SLASH mechanism, and placing the label on the slide within the allowable range.

Once the user inputs the preprinted labels and slides into the SLASH, a system made up of a custom density polyethylene channel, gear driven rollers, sensors and moves and aligns the labels above the slide then places it on the slide asccurately. Additionally, a display informs technicians of the status of the machine.

TEAM MEMBERS

Mohammad Ahmad Al-Yaqoub, *Electrical & Computer Engineering*
Cole Daniel Carrigan, *Mechanical Engineering*
Sarah Alison Gilliam, *Biomedical Engineering*
Xylia Amairani Marquez Garcia, *Systems Engineering*
Randi Nicole Shaeffer, *Systems Engineering*
Aaron T. Winkle, *Electrical & Computer Engineering*

COLLEGE MENTOR

Steve Larimore

PROJECT ADVISOR

Vy Nguyen

Noncontact Cell Concentration Detector

Team 22007

Roche

PROJECT GOAL

Estimate the concentration of human cells in a solution within a vial without making contact with the contents of the vial.

Many medical screening devices require a different number of cells depending on their concentration in the specimen. Being able to detect the concentration of relevant cells before the test without disrupting the specimen will increase the speed at which the screening device can operate.

This design consists of an LED light source that illuminates the contents of the vial and a photodiode detector that detects the optical power emitted from the cells.

Autofluorescence, whereby biological molecules absorb light at one wavelength and emit it at another, differentiate diagnostically relevant cells from other contents. Optical filters tune the emission spectrum of the light source and the responsivity of the detector so only the relevant cells fluoresce and emit light in the wavelength band to which the detector responds. A Raspberry Pi microcontroller converts the voltage response from the detector to concentration and displays it on a screen.

TEAM MEMBERS

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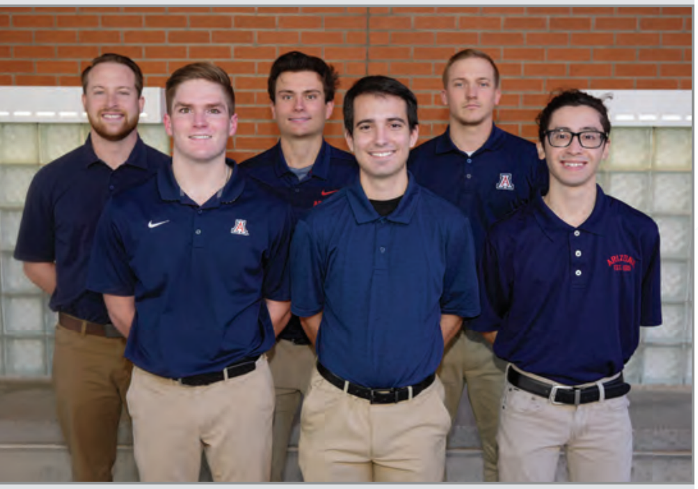
Michael Selep



Mechanical Putter Performance Pendulum

Team 22008

PING®

PROJECT GOAL

Create a putter swing system that can adjust a putter on six different axes points and repeatedly swing a putter.

Measuring golf club performance is difficult because it involves dual analysis of the club's mechanical characteristics as well as player perception and interaction with the club. A mechanical apparatus that emulates the swing but removes player variability can help determine if design changes improve a putter.

This team created a mechatronic system to precisely and consistently test putter performance. The system repeatedly mimics the swing of a putter, changes the swing parameters as desired, and analyzes outcomes. The team's design incorporates a combination of mechanical and electrical systems to precisely place the putter face, enabling analysis at various points of impact. The heart of the system is an MPP1428 servo motor that allows for precise swing motion and adjustable swing speed up to 8 mph.

Using two linear rails combined with servo motors, precise adjustments are made in the X and Z axes, with height adjustment integrated into the system's swing arm. The performance putter pendulum includes continuous yaw axis adjustment using a worm driven assembly, which can be locked in place to ensure consistent swings. The pitch axis of the swing can be adjusted 0 degrees to 20 degrees via a custom motor mounting system and quick release pins. A separate pitch adjustment independently changes that parameter for the club to remain at its typical 20-degree lie angle.

TEAM MEMBERS

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COLLEGE MENTOR

Huy Le

PROJECT ADVISOR

Curt Pawley

Low-Cost Drone Tracker

Team 22009

Ball Aerospace & Technologies Corp.

PROJECT GOAL

Design and develop a low-cost optoelectronic drone-tracking prototype that alerts the user to the drone's direction and motion.

The proliferation of drone technology presents unique security threats and public safety challenges. Drones can attain high speeds and have the potential to carry explosive payloads, conduct illicit surveillance and smuggle contraband. These small and nimble aircraft are difficult to detect with traditional radar systems. Miniaturized drones, with their small-scale radar cross section, also are hard to differentiate from other things, such as birds and high-altitude aircraft.

A network of optoelectronic drone tracker systems dispersed around a monitored airspace could address certain limitations of existing warning systems and enable greater situational awareness of drones.

Team members developed a prototype to detect, identify and track drones in real time, with concurrent reporting through a computer interface. The system automatically scans for and detects drones, recognizing them in comparison to other airborne objects. This prototype processes images from two separate camera subsystems to make positioning decisions for tilt and rotation motors and keep the object-of-interest within its field of view. The drone's direction, speed and distance are measured and reported through a graphical user interface.

TEAM MEMBERS

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Sebastian Valencia, *Optical Sciences & Engineering*
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COLLEGE MENTOR

Mike Nofziger

PROJECT ADVISOR

Benjamin Cromey

Microscope Slide Cleaning System

Team 22010

Roche

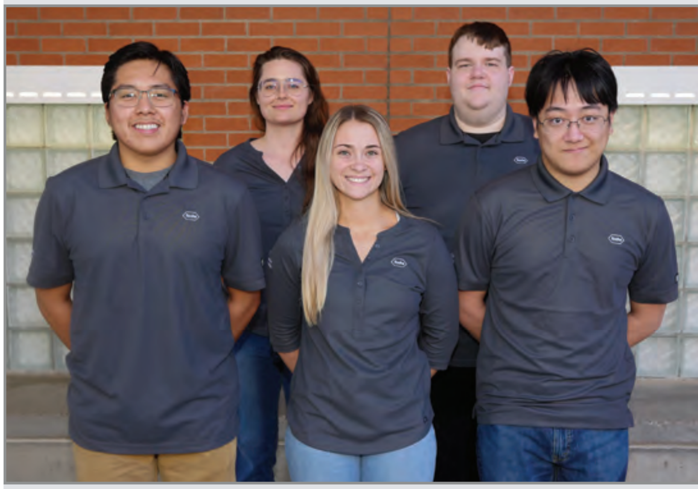
PROJECT GOAL

Design and develop a working prototype of an automated microscope slide cleaning system.

Histology workflow for preparing tissue samples on microscope slides is an intensively manual process. The HE 600 automates the process, but the slides output often have residue and other surface artifacts that must be cleaned before a pathologist can analyze them.

This project presents a prototype of an automated cleaning system that eliminates the time-consuming step whereby histo-technicians manually clean the slides post-processing and reduces the possibility of complications during sample analysis. This team extensively tested different cleaning methods utilizing design of experiments, verified an optimal cleaning process and developed a single axis machine design to automate the cleaning process.

A linear actuator, controlled by a Raspberry Pi, lowers the slide between two rotating rollers, where cleaning solution and rinse are dispensed via two nozzles. The slide is then raised to its original location and passes through additional nozzles blowing a controlled air stream to dry the surface. A camera captures before and after pictures of the slide, and the images are stored for reference. Users interface with the controller through a touch screen, and an emergency stop is integrated into the system. The system cleans 20 slides in 15 minutes, conforming to the processing rate of the HE 600.



TEAM MEMBERS

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Mark Brazier

PROJECT ADVISOR

Matt Mette

Wearable Pulsed Electromagnetic Field Sensor for Clinical Trial Compliance

Team 22011

PROJECT GOAL

Develop a product to monitor treatment and promote patient compliance in clinical trials.

Regenesis Biomedical has an FDA-approved pain treatment device in clinical trials. However, the device does not monitor treatment administration for patient compliance. Patient non-compliance can exacerbate an already lengthy and costly trial process.

This project presents a wearable device that senses treatment to increase patient compliance.

The team's design, worn on a patient's wrist, consists of multiple components. The device housing – produced with computer-automated design software and printed with biocompatible material on a 3D printer – is similar to a watch. Circuitry on a printed circuit board detects administration of treatment. A microcontroller reads in treatment detection data and uses Bluetooth technology to connect to a downloadable mobile iOS application. In addition to providing treatment information, the app includes account setup and login capabilities. Patient status reports are sent to the trial's point of contact for compliance monitoring.

TEAM MEMBERS

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COLLEGE MENTOR

Elmer Grubbs

PROJECT ADVISOR

Erica Tassone

College of Engineering Software Factory

Team 22012

PROJECT GOAL

Design and implement an online cloud-based environment to provide engineering students access to common tools used throughout the software development life cycle.

Historically, teams of developers built software, then operations teams deployed the software into production. Modern software development merges the two teams to ease transition from development to deployment. Thus, to be competitive in the workforce, software engineers need experience defining software requirements, developing architectural and detailed design models, writing code, creating automated tests and building scripts within a DevOps pipeline.

This team designed, built and tested a cloud-based platform, commonly referred to as a software factory, to help students in the college's software engineering degree program gain these experiences.

The engineering software factory has a minimum of one software tool for each phase of the software development life cycle and can easily be expanded to support additional tools. The software factory supports a continuous integration/continuous development DevOps pipeline, mirroring modern practices and automation. The team developed a containerized microservice architecture using Docker to provide scalable resource allocation depending on student demand. The platform is hosted on the College of Engineering's high-performance computing network, maximizing the power of idle servers. The team then built the front-end graphical user interface for students to easily access the cloud-based software development environment.

TEAM MEMBERS

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COLLEGE MENTOR

Sharon ONeal

PROJECT ADVISOR

Sharon ONeal

Improved Decluttering of Aircraft Cockpit Traffic Displays

Team 22013

L3HARRIS | LATITUDE ENGINEERING

PROJECT GOAL

Declutter aircraft cockpit displays to increase situational awareness of pilots in areas with high traffic density.

Commercial aircraft have a transponder to transmit position, altitude and velocity to other aircraft that helps pilots determine potential risk of aircraft collisions along their flight paths. In high-density areas, the traffic display becomes cluttered with information, making it difficult to use.

This project presents new software to predict aircraft trajectories. It displays only the most relevant information to assist pilots during flight, increasing situational awareness and reducing the risk of collisions.

The team expanded an existing machine learning algorithm to accurately predict aircraft trajectories and implemented several techniques to declutter pilot traffic displays. The software design, developed using Python, continuously creates projected paths for all available aircraft up to three minutes into the future and updates the traffic display every five seconds. The design compares future flight paths to determine whether any aircraft will be in the traffic advisory area minutes before a warning is announced. Mean squared error calculations determine the accuracy of predicted values against their true values, and the display reverts to unfiltered data when accuracy is below 96%. The user can toggle between multiple display options within seconds. The students' Decluttered Aircraft Traffic Display System is expected to show predicted collision risks before the traffic collision avoidance system calls out warnings.

TEAM MEMBERS

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Subscale Adsorption and Compression CO2 Removal System Redesign

Team 22014

NASA SAM

PROJECT GOAL

Integrate carbon dioxide removal and compression into a single system for a newly designed TS-TSAC geometry that can be scaled up.

This project required redesign of NASA's previously developed Thermally Coupled Temperature Swing Adsorption and Compression (TS-TSAC) systems, providing an air revitalization alternative to assist in the agency's Moon to Mars exploration objectives.

For the Moon to Mars eXploration Systems and Habitation, or M2M X-Hab, challenge, the model uses new goeometry to continue the exploration of combining carbon dioxide removal and compression into one system. The system consists of two half-cycles whereby packed beds of regenerable bulk sorbents and heat cycles simultaneously adsorb and compress carbon dioxide.

The team designed the adsorption and compression beds in a cylindrical shape to maximize air flow. A desiccant helps lower humidity levels and the sorbent Zeolite 13X to capture carbon dioxide. Sensors monitor both, and a custom heater in the adsorption bed regenerates the sorbent. The experimental system is expected to scale up to 4 kg of carbon dioxide removal per day. The team produced multiple design alternatives.

TEAM MEMBERS

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COLLEGE MENTOR

Doug May

PROJECT ADVISORS

John Adams, Kai Staats

Low Size, Weight, and Power Forward Motion Blur Correction for Airborne Imaging

Team 22015

Areté
DISCOVER. DEVELOP. DELIVER.

PROJECT GOAL

Translate the focal plane of a camera at a rate that compensates for aircraft movement relative to ground speed to correct for forward motion blur.

Motion blur when forward moving aircraft take images of ground objects has been remedied with expensive camera gimbals, which use motors and intelligent sensors to support and stabilize a camera. This project aims to translate the focal plane of the camera to create line of sight stabilization that corrects for forward motion blur, thereby eliminating the need for a gimbal.

The team's Low Size, Weight and Power (SWaP) Forward Motion Blur Correction for Airborne Imaging device (FMBC) translates the focal plane of the camera at a rate that compensates for the relative speed of the ground object so stationary objects do not appear blurry on the detector of the camera.

A monochrome camera, imaging lens and motorized linear translation stage make up the FMBC system. The camera is attached to the stage to allow back and forth movement to correct for motion blur when in flight. The SWaP design interfaces with LabVIEW and Vision software to test the quality of the corrected images. However, because the FMBC device could not be tested in a flight environment, the team used a ground vehicle to simulate forward motion.

TEAM MEMBERS

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Real-Time Instrument Characterization Kit (RICK) v4.0

Team 22016

Roche

PROJECT GOAL

Determine the viability of strain gauges as an adequate solution for estimating the volume of staining fluid dispensed on a slide within the BenchMark ULTRA system.

Being able to ensure correct volumes of staining fluid for specimens allows for more reliable testing. Roche Tissue Diagnostics wishes to test and analyze the viability of using strain gauges to estimate volumes of mostly liquid specimens on slides as they are stained in the BenchMark ULTRA staining system.

Because strain gauges typically estimate mass, or weight, this system must use a known density to reverse-calculate the weight.

In addition to the viability study, the team designed a device to fit within the BenchMark ULTRA for RICK v4.0 testing. Specifications included withstanding temperature and humidity fluctuations as well as the system vibrations during the staining without impeding the process or making it more difficult for technicians. The outcome was a system that employs a microcontroller, load cell with a four-strain gauge system running through a signal amplifier, and various methods of power regulation.

TEAM MEMBERS

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Mark Allen McDaniel, *Electrical & Computer Engineering*
Yash Patel, *Systems Engineering*
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COLLEGE MENTOR

Mark Brazier

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Derek Fung Correa

Launch Vehicle Frontend Cover and Retraction System

Team 22017

NORTHROP GRUMMAN

PROJECT GOAL

Design a reuseable frontend cover and retraction system for a launch vehicle.

Northrop Grumman uses flythrough covers to cloak the shapes of launch vehicles and protect their frontends from environmental conditions. However, these covers are not reusable.

This team tested and modeled a reusable frontend cover and cable and spool retraction system, whereby the cover can be removed without recontacting the vehicle.

The cover has a clamshell-like opening and is made of a soft, durable, inflatable material. It protects the vehicle from high temperatures, wind, precipitation and humidity and can be used two or three times within a year. The easily assembled, operated and transported retraction system can be adapted to different launch sites and vehicle heights.

TEAM MEMBERS

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PROJECT ADVISOR

Sierra Rose

Electronic Continuously Variable Transmission

Team 22018

COLLEGE OF ENGINEERING
Electrical & Computer Engineering

PROJECT GOAL

Create an electronically controlled continuously variable transmission prototype for the University of Arizona Baja SAE team.

Every year, the University of Arizona Baja Society of Automotive Engineers team designs and builds an off-road vehicle to race against other schools in competition. The car has a mechanical continuously variable transmission (CVT). It has pulleys, which use internal flyweights and springs for actuation, that vary their diameters depending on engine RPM and load coming from the gearbox.

This project presents a more efficient method that controls the pulley diameter electronically.

The team modeled and designed a system consisting of two pulleys, two motors, two linear actuators, hydraulics, three microcontrollers, an RPM sensor, and a housing to protect the electronics. Additionally, the team implemented a controls algorithm based on modeled vehicle dynamics to determine the proper gear ratios for optimal performance. The students integrated and tested the system on the club's 2021 Baja competition car, finding that it displayed superior durability, tunability and control.

TEAM MEMBERS

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Eric Anthony Duarte, *Engineering Management*
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PROJECT ADVISOR

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Thrombus Growth and Adhesion to Tube Wall

Team 22019

PROJECT GOAL

Develop a method to increase thrombus adhesion in a set of artificial arteries for bench testing of atherectomy and thrombectomy devices.

Bench testing is key to the safety and efficacy of medical devices. Models must be extraordinarily similar to the anatomy of the human body to generate valid data before devices can be tested on humans.

This project demonstrates a more realistic model of thrombus adhesion to blood vessels in the human body. The design encompasses multiple components to represent an adhered thrombus, including various sizes of tubing, grooving patterns on the interior wall of the tubing, and collagen coating on the interior tubular interface.

Specifically, the team used three tubing sizes to represent different functions of blood vessels ranging in diameter from 3 millimeters to 10 millimeters. The interior wall of the tubing was scored and coated with a collagen solution to increase thrombus adhesion. The components designed for bench testing closely modeled actual human blood vessels.

TEAM MEMBERS

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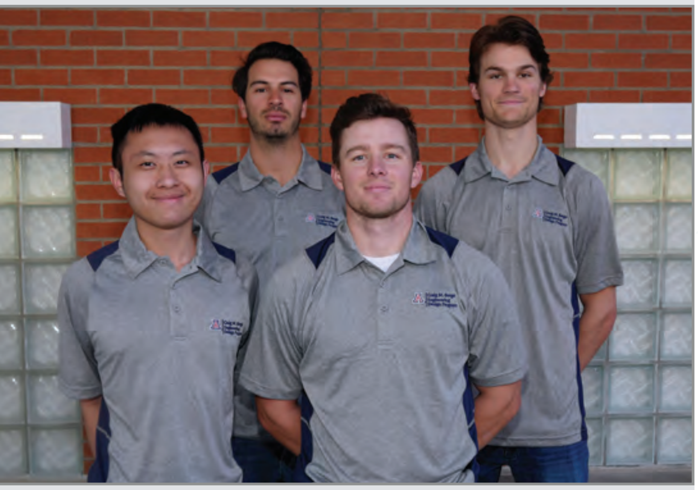

Modular Mosquito Surveillance Research Trap

Team 22020

PROJECT GOAL

Create an efficient user-friendly mosquito trap that reduces field time and increases specimen yield for vector control agencies and research teams.

Mosquitoes transmit deadly diseases and viruses. Entomology researchers place surveillance traps to capture the insects alive and determine what diseases they are carrying. These traps, which are cumbersome, rely on the production of carbon dioxide to attract mosquitoes.

This design combines two modular subsystems: the mosquito lure and environmental sensors. The lure uses a one-pound propane tank with safety mechanisms to produce carbon dioxide at preprogrammed times. Environmental sensors collect data while the propane is releasing carbon dioxide into the environment.

Combustion components include a solenoid valve and electronic piezo igniter controlled by an Arduino. A tilt switch stops combustion if the tank is knocked over or tampered with. Sensor components include a GPS, thermometer, humidity sensor and atmospheric pressure sensor. The data is collected on a removable SD card controlled by the same Arduino Mega 2450 Board coded in C++.

TEAM MEMBERS

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Jake Whitehead, *Mechanical Engineering*

COLLEGE MENTOR

Bob Messenger

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Optimal Valve Diaphragm and Membrane Design for Use in Medical Catheters

Team 22021

xeridiem MEDICAL DEVICES

PROJECT GOAL

Design, develop and verify an optimal diaphragm membrane, which can burst at a specific pressure to bypass blockages, for a medical catheter.

Medical catheters are tubes inserted in body cavities, vessels and ducts to drain body fluids. The diaphragm membrane is a critical component of the catheter. It bursts at a certain pressure when a blockage occurs to allow fluids to flow through the opening created. One such use for this membrane design would be in a brain shunt to drain cerebrospinal fluid. Because of the body's sensitivity to pressure, especially in the brain, the membrane must burst at a specific pressure to ensure no damage is done to the brain. These ultrathin membranes are difficult to produce.

This team developed a method to achieve the same burst pressure in the membrane while ensuring a consistent manufacturing process. The approach focused on creating a diaphragm membrane with an intentional slit geometry to act as a weak point and burst at a given pressure, providing an alternative path for fluid drainage. The students anlyzed several slit geometries and corresponding manufacturing capabilities.

The slits in the membrane were produced using a laser ablation device. The membrane was made from biocompatible liquid silicone rubber to minimize adverse affects on surrounding tissue. The team pressure-tested its design, and, with a durometer, measured the hardness of the silicone. To ensure the system was reproducible, the team analyzed capability and performance standards using the PPK process.

TEAM MEMBERS

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Sydney Schreiner, *Biomedical Engineering*
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COLLEGE MENTOR

Steve Larimore

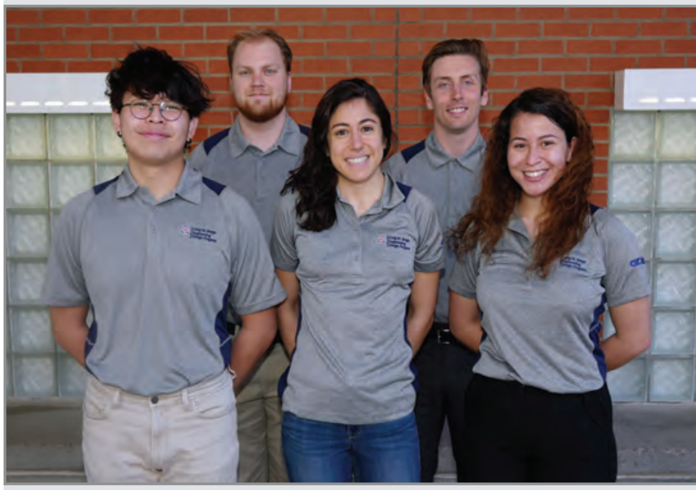
PROJECT ADVISOR

Paul Melnychuck

Software Defined Radio System on Chip FPGA Prototype

Team 22022

GENERAL DYNAMICS Mission Systems



PROJECT GOAL

Develop FPGA functions for a software-defined radio to investigate the performance limits of the Xilinx Ultrascale System on a Chip.

Modern technology is providing new functionality for data processing interactions between general purpose processors (GPPs), field programmable gate arrays (FPGAs) and radio frequency integrated circuits (RFICs). Systems on a chip (SOCs) open up the bottlenecks when GPPs and FPGAs are implemented into different integrated circuits. Software-defined radio (SDR) boards include RFIC radio frequency integrated circuits that reduce size, weight and power while improving performance.

This project involved prototyping FPGA software to to evaluate the capabilities of the Rincon Raptor board. The team examined the types of processing performed in SDRs, developed an architecture to exploit the interfaces supported by the SOC and prototyped and evaluated an RFIC/FPGA/GPP implementation on SOC hardware.

The team developed signal processing functions in VHDL to find the limitations of the Raptor board's data rate. Equipped with a Xilinx UltraScale SOC, featuring a combination of a traditional general-purpose processor and FPGA, the Raptor board acts as an ideal environment for development. This setup allows for quicker signal processing speed.

TEAM MEMBERS

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COLLEGE MENTOR

Elmer Grubbs

PROJECT ADVISOR

Randy Derr

DF North Offset Drone Test Module (NODTM)

Team 22023

GENERAL DYNAMICS
Mission Systems

PROJECT GOAL

Fabricate a module housing that is transportable via drone and capable of transmitting a VHF at specific intervals as well as logging position, time and duration.

General Dynamics Mission Systems performs periodic preventative and corrective maintenance on all of its Rescue 21 direction finding (DF) radio towers for the U.S. Coast Guard. A new true north offset line of bearing must verify direction during tower maintenance. Previously, the costly process involved sailing a boat along a specific path or driving a vehicle on difficult terrain to take measurements with specialized equipment.

This project presents a lightweight, modular attachment for a drone that effectively and efficiently calibrates DF radio towers.

The design attaches a small module with data recording/measuring capabilities to a DJI Mavic Air Drone. Drone pilots toggle on power to the module, activating the Arduino microcontroller and initiating data recording. As the DF North Offset Drone Test Module (NODTM) transmits very high frequency (VHF) signals at specific time intervals during flight around the tower, it simultaneously records and stores position, time and duration data. The data is exported as a single log file and post-processed to produce a DF tower calibration.

TEAM MEMBERS

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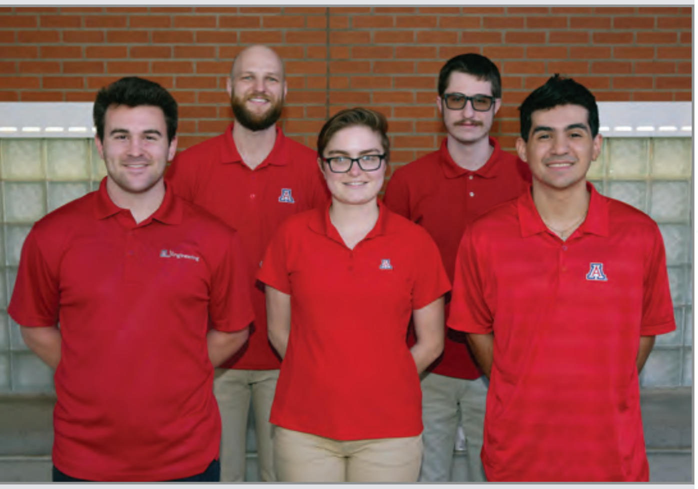

Gas Pycnometer for Determining Density and Porosity of Returned Asteroid Bennu Samples

Team 22024

COLLEGE OF SCIENCE
LUNAR & PLANETARY LABORATORY

PROJECT GOAL

Using nondestructive and noncontaminating measurement methods in a curation environment, accurately measure the porosity of mineral samples collected from Bennu.

Density and porosity measurements are critical to analyzing asteroid samples, typically found on Earth. The OSIRIS-REx project presents a unique opportunity to analyze carbon-rich samples from an actual asteroid, Bennu. Accurate porosity measurements can indicate trapped moisture during the formation of an astronomical body.

The team applied gas pycnometry theory to design a system that mitigated risk of sample contamination and damage, met material and spatial requirements, and accommodated various sample sizes.

The students used error analysis and modeling to determine optimal volume and number of reference chambers. Without lubricants, non-approved materials or shearing contact points, they designed a novel chamber with a gas-tight seal. They used a pressure transducer and LabVIEW VI for measurements. The team combined pressure measurements, the ideal gas law, and 3D sample measurements to determine porosity. Automation allowed for rapid repetition, minimal change in the sample environment, and precise measurements.

TEAM MEMBERS

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COLLEGE MENTOR

Doug May

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Andrew Joseph Ryan

Voice Recognition System With Direction, Translation and Display

Team 22025

McDonald/Watt Projects

PROJECT GOAL

Provide a tool for deaf individuals to communicate independently in a group setting through the use of voice-to-text within an iOS application and microphone array system.

Many hard of hearing or deaf individuals depend on a translator or lip reading in group settings.

The Smart Voice Recognition System (SVRS) design helps users identify what a speaker is saying via voice-to-text, who the speaker is, and where they are located in a room – all using an iPad graphical user interface (GUI). Wireless transfer of direction information and audio files ensure ease of use and portability.

SVRS incorporates a neural network learning model to accomplish the voice recognition component. A built-in voice-to-text framework provides real-time mapping from speech to text. Filtered audio detected by the microphone array and defined by a GUI arrow identifies directionality. A Raspberry Pi connected to the microphone array houses all of the directionality software. The application that houses the voice recognition and voice-to-text software is loaded onto an iPad. And, the iPad and Raspberry Pi are connected via wireless ad-hoc network using MQTT.

TEAM MEMBERS

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Don McDonald

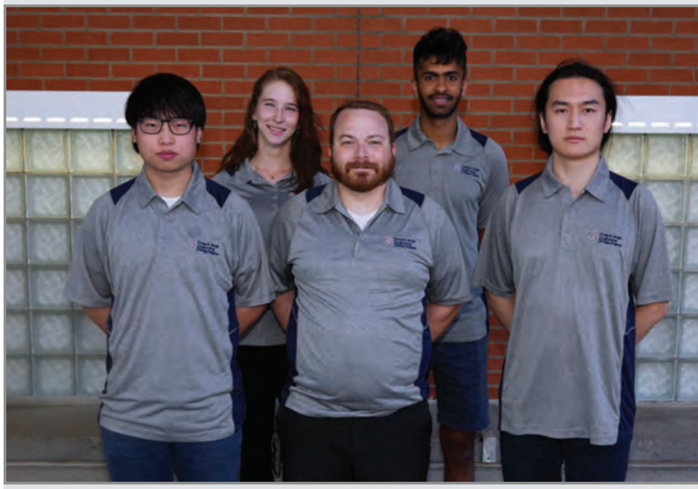
PROJECT ADVISOR

Don McDonald

A Real-Time Vegetation Stress Detection System on a Drone

Team 22026

COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING
Biosystems Engineering



PROJECT GOAL

Detect stress levels in agricultural crops in a given area and present results visually in an easy-to-use user interface.

Vegetation stress is a key indicator of crop health, which often is determined using manual field analysis. This project presents a real-time drone analysis as a cost- and time-saving alternative. The Crop Level of Stress Analysis with Visual Export (CLOSAVE) software system can detect and categorize the level of stress in vegetation leaves.

The design is split up into two elements. The primary element is the CLOSAVE software, which receives video from a drone as it flies over a crop and then uses machine learning algorithms to indicate areas of stress detected on the plant. A commercial off-the-shelf color camera captures the video, and the software is pre-trained to recognize vegetation stress indicators. The second element is a drone, custom-built entirely by the team, that uses parts tailored to the design requirements of the software.

TEAM MEMBERS

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Haley Boyd, *Biosystems Engineering*
Matthew Phillip Wolfgang Hevert, *Optical Sciences & Engineering*
Caiyue Lai, *Electrical & Computer Engineering*
Edward Zhu, *Electrical & Computer Engineering*

COLLEGE MENTOR

Mike Nofziger

PROJECT ADVISOR

Kamel Didan

PV to EV

Team 22027

Tucson Electric Power

PROJECT GOAL

Design and build a solar photovoltaic power converter system that can charge a modern electric vehicle without connecting to the electric grid.

Tucson Electric Power aims to provide 70% of its power through renewable energy sources and reduce carbon emission levels by 80% by 2035. As the electric vehicle market increases, one part of meeting these goals is expanding the availability of affordable solar-powered electric vehicle charging stations.

This standalone system converts solar energy into electricity using a Maximum Power Point Tracking feature, a technique that optimizes the variable solar power input energy. This optimal energy is then extracted and routed to the charging circuit subsystem that contains a 240kV step up isolation transformer and a buck converter that steps down the voltage to power an Arduino MEGA 2560 microcontroller. The Arduino monitors and communicates digital control to the closed-loop cooling subsystem to keep the internal temperature within operable limits.

The solar charging circuit, microcontroller and cooling system are enclosed in a National Electric Manufacturers Association 3R-rated external housing system, making the off-grid solar power converter able to withstand extreme weather conditions. This system will allow users to charge electric vehicles directly from solar panels without grid interconnectivity.

TEAM MEMBERS

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COLLEGE MENTOR

Justin James Hyatt

PROJECT ADVISOR

Christopher Lynn

Connecting Virtual to Reality: Joining VR With Complex Opti-Robotics

Team 22028

AIRY OPTICS
THE POLARIZATION EXPERTS

PROJECT GOAL

Control the geometric phase of an optical beam using maneuverable mirror systems in linked virtual reality and physical spaces.

This project presents a proof-of-concept demonstration of geometric phase in an optical system, using out-of-plane mirror systems. The team built the physical mirror system with actual hardware, while they "built" the identical virtual mirror system inside of the Airy Optics VR Lab environment. The two mirror systems are linked through software so users can interact with either system to alter one or both mirror sets. The two systems can operate independently or in sync.

In the physical space, the team designed a frame that uses motors and motor drivers to enable precise rotational and linear movement of the mirrors. A custom Mathematica algorithm precisely aligns them using a generated list of 800 possible configurations. A laser with a customizable initial geometric phase propagates through the mirrors, and a polarimeter measures the polarization change. The physical system is controlled by a standalone Java application, which can communicate with the virtual system.

In the VR space, a corresponding set of mirrors displays real-time ray tracing using Polaris-M. The virtual subsystem consists of the virtual mirror setup and a graphical user interface to control each mirror position, both of which run with the Unity engine. A user can specify the polarization angle change in the optical subsystem, which alters the mirror positioning in both systems.

TEAM MEMBERS

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Carter Conway

Manufacturing Automation

Team 22029

COMPETITIVE ENGINEERING INC

PROJECT GOAL

Design, program and implement an automated system to inspect the flatness and dimensional tolerance of a manufactured component.

Automated systems can optimize production and daily operations in manufacturing environments. Competitive Engineering Inc. seeks to maintain quality standards by automating the process of inspecting a gear for flatness and dimensional accuracy. The team designed a system to safely complete the inspection process with repeatability and flexibility.

The system design includes a UR5 robotic arm equipped with a custom vacuum gripper, a Gocator 3D laser profile scanner and a Keyence dimensional inspection tool. The team machined fixture plates with unique rod patterns to hold gears in the correct orientation for inspection. The design focuses on the compatibility of the fixtures with the Vention workbench, vacuum gripper and the 5th Axis mounting plates. The robot is programmed to load and unload gears throughout the system while managing the results of each inspection. The system can efficiently inspect and categorize without operator interaction.

TEAM MEMBERS

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PROJECT ADVISOR

David Saucedo

BRITE: Blinding Resonant Incapacitating Throwable Emitter

Team 22030

Elbit Systems™

PROJECT GOAL

Develop and deploy an incapacitating, yet safe and reusable, electronic flashbang grenade.

Flashbangs used for military or law enforcement purposes are explosive by nature and therefore potentially harmful not only to the assailant and the user, but also to the surrounding environment. Commercial electronic flashbangs attempt to replicate the size and appearance of traditional flashbangs, but may not be powerful enough to be incapacitating while remaining unharmful in the long term. The BRITE is a more versatile alternative to these flashbangs.

Powered by a rechargeable battery and equipped with high-powered LEDs and buzzers, the BRITE can be controlled remotely and run continuously for five minutes. High-powered LEDs flash at a blinding frequency and a 110 dB buzzer goes off to disorient and distract assailants. All components are housed in a cylindrical tube made of hard plastic with soft, hexagonal end caps to absorb shocks during use.

TEAM MEMBERS

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Matthias Whitney

Recording Fetal ECG With a Biomagnetic Sensor

Team 22031

PreTeL

PROJECT GOAL

Create a fetal heart monitoring system using a biomagnetic sensor.

The objective of this project is to create a fetal heart monitoring system. The system redirects magnetic field lines and uses frequency filtering to reduce noise in order to create a magnetocardiogram (MCG). The use of a novel biomagnetic sensor makes it possible to capture the fetal heart signal in a clinical environment.

The team developed a fetal heart simulator, a flux condenser, a multilayered magnetic field barrier and digital filters. The fetal heart simulator emulates relevant aspects of the electrical and magnetic activity of a fetal heart for testing purposes. The flux condenser collects and redirects magnetic fields originating from the fetal heart simulator to the sensor. The multilayered magnetic field barrier attenuates external magnetic fields. The digital filters eliminate unwanted magnetic field signals, leaving only the targeted cardiac signal. The result of this project is an MCG that displays a cardiac signal comparable to that of a fetal heart.

TEAM MEMBERS

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PROJECT ADVISOR

Roger Young

MIS Flatfoot Reconstruction

Team 22032

Paragon 28 — Exclusively foot & ankle

PROJECT GOAL

Design and develop a guide system and use method to allow minimally invasive flatfoot reconstruction procedure.

Flatfoot, which affects nearly 8 million individuals in the United States, occurs when the longitudinal arch in the foot collapses. Current techniques to correct flatfoot involve making large, 5-inch incisions, which may lead to longer healing times and soft tissue damage. While standard tools are used in the process, there is no standard technique or procedure.

The team developed a surgical guide system that will be placed on the outer side of the foot. Surgeons can use a custom burr remove cartilage material from the three spaces within the joint and prepare the space for flatfoot reconstruction. The guide and burr will work together to aid the surgical team in removing cartilage between the two bones. A surgeon can use the designed instrumentation to operate within a small incision (less than 1 inch) with adequate visualization of the bone. The curvature of the guide helps surgeons navigate safely through the joint when using the burr and provides a level of standardization to the surgical procedure. The system follows all medical device regulations and is crafted from ASTM F899 surgical steel.

TEAM MEMBERS

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COLLEGE MENTOR

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PROJECT ADVISORS

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Remote Activated Enrichment Dispersal Unit

Team 22033

PROJECT GOAL

Develop a remotely activated device capable of delivering enrichment items of various shapes, sizes and weight to the Andean bear habitat at Reid Park Zoo.

Enrichment items are an essential aspect of animal care within zoos. Traditionally, zookeepers remove the animals from their habitats, then manually stage the enrichment items before bringing the animals back. The team designed this device to reduce animal dependency on and interaction with zookeepers, while making animal enrichment more efficient.

They modeled the design after a standard chain-driven bucket elevator, sometimes seen in industrial and agriculture settings. The team designed a frame built with reinforced 2x4 and 4x4 lumber to emphasize structural integrity, longevity and animal safety. Equipped with a total of six buckets, the device can be pre-loaded with up to three enrichment items at a time. The team also custom designed sprockets to provide proper tension to the chain and reduce wobbling of the item-bearing buckets.

The system is driven by a 1/8 horsepower motor that uses gear ratio advantage to ensure adequate torque to move the weight of the fully loaded system. The device automatically tracks the positioning of the buckets to ensure proper delivery of enrichment items using a limit switch and Arduino controller. Zookeepers can activate the device remotely using a 433 MHz transmitter and receiver, which enables the deployment of the preloaded items individually at any time.

TEAM MEMBERS

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Stephanie Norton

Elephant Pellet Dispersal Unit

Team 22034

PROJECT GOAL

Create an autonomous, programmable device to randomly distribute elephant pellets to various locations within a habitat.

Elephants walk extreme distances to forage for food in wild habitats. To simulate a more realistic environment for the elephants at the Reid Park Zoo, the team created a device that uses a programmable control system to distribute food pellets throughout the elephant habitat. The device can operate in harsh Arizona weather conditions and includes a refillable hopper to minimize zookeeper interaction with the animals. The remotely operable device aims to further the realism of the elephant habitat by encouraging more elephant exercise, requiring them to search for food rather than depending on human interaction. The most important design constraint was ensuring that the device does not cause any harm or distress to the elephants.

To allow zookeepers to easily operate the system, the unit includes a touchpad interface to program launch times, distance and angle; a remote to initiate launches from a distance; a large-capacity storage hopper; and a pneumatic pellet launching mechanism.

TEAM MEMBERS

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PROJECT ADVISOR

Stephanie Norton

Next-Generation Aircraft Lithium Battery Automated Fixture

Team 22035

MEGGiTT

PROJECT GOAL

Design and build a prototype semi-automated fixture to apply a heater blanket precisely and consistently to a set of battery cells.

The manufacturing of safety-critical systems, such as aircraft battery packs, requires a high level of precision and consistency that is difficult to achieve with human labor alone. Factory automation presents an opportunity for manufacturers of such systems to significantly improve the quality and efficiency of their operations. This team designed and built a low-cost, portable fixture to automate the attachment of an adhesive heater blanket to a set of battery cells.

The final design uses a series of stepper motors attached to 3D-printed clamp arms. The motors are controlled by a Raspberry Pi running Python code developed by the team. Attached to the Pi is a touchscreen which displays a graphical user interface (GUI). Users of the system can load a set of battery cells into the fixture and clip a heater blanket to the clamp arms. The GUI can then start the application, which consists of the clamp arms automatically closing around the battery cells and in the process accurately adhering the blanket to the cells. The system also features an emergency stop function, allowing the user to halt the application of the blanket at any point.

TEAM MEMBERS

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Robotic Platform for Autonomous Vehicle Safety Assessment

Team 22036

Tucson Embedded Systems

PROJECT GOAL

Simulate real-world interactions for autonomous vehicle training through the development of a small, scaled semi-autonomous vehicle that can accurately track its kinematic qualities.

Self-driving cars, or autonomous vehicles, have come a long way, but there is still much research to be done and many improvements could be made, particularly when it comes to human safety. The team has partnered with the Institute of Automated Mobility on simulating real world-driving situations to help and train autonomous vehicles for interactions with traditional automobiles. The design uses a preexisting axial radio-controlled car with enhancements of the wheels, suspension and frame to facilitate the sensor package data collection for position tracking. The team designed a visual tracking system and mounted it to the chassis for camera recognition. These enhancements calibrate and validate the visual tracking, while natively storing the position of the vehicle as it navigates its environment.

TEAM MEMBERS

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Elmer Grubbs

PROJECT ADVISOR

Jonathan Schwab

Rapid Multispectral Imaging of Physiologic Processes

Team 22037

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

Design an RMIS capable of reliably viewing and analyzing blood content and other physiological processes in the human body.

Understanding and analyzing the human body's physiological processes can be useful, but most of them cannot be seen with the naked human eye. Processes that could be of interest include blood content, oxygen levels, and perspiration levels – all of which directly relate to overall human health. This project offers a safe, low-cost and efficient way to image physiological processes.

The system hardware consists of 13 pairs of LEDs of varying wavelengths connected to an imaging system. The camera collects an image with each LED pair turned on, along with a single image with all LEDs turned off, resulting in 14 total images per system cycle. The Rapid Multispectral Imaging System (RMIS) can collect 500 photos per second and provide 10 frames per second of video output. After the photos are captured, the Python code calibrates the image using techniques such as flat field correction and background subtraction. Based on the optical properties of the imaging target, the code then analyzes the calibrated images to obtain physiological data. The resulting images are displayed on a graphical user interface, which also contains options for selecting the imaging target, analysis, wavelength and physiological data of interest. The system offers a wide range of applications in medical research and allows for adjustments to meet the needs of specific scenarios.

TEAM MEMBERS

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COLLEGE MENTOR

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PROJECT ADVISOR

Urs Utzinger

Cleaning of Eutectic No-Clean Solder

Team 22038

Honeywell

PROJECT GOAL

Determine the effects of environmental, build and flux factors that cause dendritic growth on manufactured circuit boards during use.

Circuit board longevity is a key factor in electrical and electronic equipment. Boards are constantly introduced to varying environmental conditions, including extreme heat, high relative humidity and below freezing temperatures. The specific production processes used along with the differing levels of voltages applied introduce even more variables that may impact longevity. It is necessary to understand why some boards fail. The team designed an experiment which tests key factors to provide data and understand failures of printed circuit boards.

The experiment is based on varying three factors: voltage, flux volume and pad spacing. The team developed a circuit board which optimized the number of tests per board while meeting design of experiment requirements. They used a humidity/temperature chamber to match desired environmental conditions, applied flux to each board at three differing levels, and applied voltage sources ranging from 15V to 50V DC. Pad spacing allowed for further variation. The boards were held under constant environmental conditions for a period sufficient to encourage dendritic growth. The team noted current leakage, recorded the time of failure and presented relevant statistics. Ion chromatography permitted further understanding of the factors causing dendritic growth and current leakage.

TEAM MEMBERS

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Parylene Conformal Coat for Circuit Card Assemblies

Team 22039

Honeywell

PROJECT GOAL

Test different methods, processes and materials for removing/stripping Parylene conformal coating from circuit card assemblies.

Parylene coating is a barrier that protects a circuit card from environmental threats, such as contaminants, moisture and temperature, while providing dielectric properties. Its durability makes it an ideal choice as a barrier, but also makes it difficult to remove when the circuit card needs to be repaired. Removal requires a lot of time, money, labor, and even dangerous chemicals, which can pose potential damage risks. In this project, the team tested and provided various methods, such as abrasion, reactive ion etching, and laser ablation, to effectively remove the coating without damaging the board. They tested the laser removal with a device they designed and built, which can be controlled by a user interface and allows for complete board and spot removal of Parylene.

TEAM MEMBERS

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Additive Heat Exchanger Advancement

Team 22040

Honeywell

PROJECT GOAL

Design an additively manufactured heat exchanger, create a modular testing apparatus and develop verification procedures for both.

Traditional manufacturing of aerospace heat exchangers is time-intensive and has a high rate of manufacturing failure. Additive manufacturing heat exchangers would allow for single part construction, reducing potential points of failure. Additive manufacturing also greatly reduces the time needed to create prototypes and allows for a significantly more complex design.

The team designed, tested and produced an additive manufactured heat exchanger prototype to meet sponsor requirements. They also created a material and machine agnostic repeatable workflow package to allow customers to replicate and continue to develop the submitted design. The team also designed and constructed a testing apparatus for verifying that the heat exchanger can meet its requirements. The test equipment can verify the water flow, temperature, pressure and internal integrity. The team also created a verification procedure utilizing the modular testing apparatus in multiple forms.

TEAM MEMBERS

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Comprehensive Modeling of Beam Propagation in Multimode Fiber and Experimental Validation

Team 22041

ASML

PROJECT GOAL

Build a comprehensive beam propagation simulation in MATLAB of a multimode optical fiber. This simulation shall estimate field distribution variations and losses due to external factors such as bending, twisting and temperature.

Optical fibers are used to perform highly accurate laser measurements in photolithography machines. External factors can affect the beam propagation in these fibers, so modifying the laser settings to accommodate the variations leads to higher yield on silicon wafers (semiconductors). This project predicts output field distribution, intensity and power loss from external effects as the light propagates through the fiber.

The team modeled the structure for simulation using MATLAB, which allows integration into the model the sponsor currently supports. The code is modular and derived from preexisting mathematical models. This allows for separate functions to simulate each of the effects independently. The team's design for the experimental validation component of the project features a supercontinuum laser, and narrow band pass filters to test individual wavelengths. The laser is then coupled into an optical fiber with a bi-convex focusing lens where the fiber is exposed to bending, twisting and thermal effects. A Newport Si power detector records the power before and after coupling.

TEAM MEMBERS

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Tao Chen

Autonomous, Low-Cost and Portable Lysimeter for Use in a Greenhouse System

Team 22042

COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING
Biosystems Engineering

PROJECT GOAL

Deliver an autonomous, low-cost and portable lysimeter for use in a greenhouse.

The Smart Lysimeter automates the process of collecting data on the nutrient solution, pH, electrical conductivity (EC), and drainage rate in a greenhouse, eliminating the need for manual labor. These metrics are crucial for maintaining the proper environment for crop growth and resource allocation. This lysimeter fills a market niche by automatically collecting all the necessary data to make real-time greenhouse operation decisions, without requiring high-tech, expensive equipment. It can also be transferred between greenhouses and crops with just a few simple steps.

The design consists of a divided tank, each side equipped with a pH probe, EC probe, fluid level sensor and pump. The two-section tank allows for monitoring of both the solution that drains out of the plants, and the solution being given to the plants. After data is collected, the solutions are pumped out of the system and into a drainage channel so they can be recycled. The team developed software to autonomously collect data from the sensors at appropriate time intervals, process the data and display it in a user-friendly manner. A Raspberry Pi serves as the microcontroller and data storage unit, allowing for a historical log of data.

TEAM MEMBERS

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COLLEGE MENTOR

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PROJECT ADVISORS

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Autonomous, Robotic Platform Harvesting Leafy/Microgreens in a Vertical Farm System

Team 22043

COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING
Biosystems Engineering

PROJECT GOAL

Create a machine that will autonomously harvest leafy greens or microgreens from a hydroponic foam growing raft. The machine will also remove and recycle the plant roots and the growing media, leaving the foam growing raft ready for reuse.

The world's population is projected to increase to 10 billion by the year 2050. Traditional agriculture is costly and inefficient compared to Controlled Environment Agriculture (CEA). New technologies have reduced the operational costs of CEA, but humans still perform the harvesting operations, which is costly. The team created a machine that reduces the need for manual labor when harvesting produce from greenhouses or vertical farms.

The machine can cut the leafy greens or microgreens, cut the roots, remove the growing media from the foam growing board and direct these items to the next step in the process. The team focused on using readily available commercial components to minimize cost and improve availability of replacement parts. The design includes hedge trimmer cutting blades, stepper motors and conveyor belts, as well as an aluminum frame with a platform that accepts foam growing rafts. The operator uses a touchscreen linked to a Raspberry Pi single-board computer and an Arduino microcontroller to indicate which product is being harvested.

This product met all of its system requirements and greatly reduced the time and labor costs associated with the harvesting operation in CEAs.

TEAM MEMBERS

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COLLEGE MENTOR

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Hyperspectral Camera

Team 22044

Raytheon Technologies

PROJECT GOAL

Design and prototype a cost-efficient, biologically inspired hyperspectral camera to identify the spectral signature of an object.

Hyperspectral cameras, which can view the unique spectral fingerprints of an object, have consumer applications including detecting the freshness of produce and validating the authenticity of currency. However, the cost and size of these devices makes it challenging to breach the consumer market with these applications. The team's nontraditional technique proved that a cost efficient design can be achieved by using a diffractive lens to create chromatic aberration.

The team researched and developed a specialized diffractive lens system with a motorized detector to create a hyperspectral imager functionally similar to commercially available ones. The lens system separates light out by color to create spectral-dependent focal planes. These focal planes are captured by a motorized detector, which is user-controlled via a Raspberry Pi. These images are sent to a separate computer, which performs image processing to synchronize the captured images with the location of the detector and identify the spectrum of an object.

TEAM MEMBERS

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COLLEGE MENTOR

Huy Le

PROJECT ADVISOR

Casey Streuber

Airfoil Cascade Hub Injection

Team 22045

Honeywell

PROJECT GOAL

Analyze the effects of altering the pressure ratio throughout a gas turbine engine by introducing a secondary flow.

In a gas turbine engine, the pressure ratio throughout the compressor stage can increase to a critical state and cause the inlet flow of air to reverse its direction. This event is known as "surge" and can lead to catastrophic damage to aircraft engines. The team designed a simplified section of a gas turbine engine and tested a potential solution: stabilizing the pressure ratio by introducing a secondary inlet flow that decreases downstream pressure.

The test piece includes a 3D-printed bottom hub and top plate, stator airfoils, and a tube that introduces secondary flow using a standard air compressor. The team selected tubing components that would cause little pressure drop from the air compressor to the main inlet flow to ensure accurate data. The mass flow rate of air introduced into the main flow is controlled by varying inlet pressure from the compressor. The velocity of the secondary flow is manipulated to decrease downstream pressure.

The team conducted testing in a wind tunnel running at 100 mph. They recorded pressure using a pitot-static tube rake, which can change height based on the pressure change during computational fluid dynamics testing. This data will inform gas turbine engine design by determining exactly the velocity needed for the secondary inlet flow to help prevent a surge event.

TEAM MEMBERS

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Nick Nolcheff

Ultra-Low Power IoT Sensors for Condition-Based Maintenance

Team 22046

Ridgetop Group Inc
ENGINEERING INNOVATION

PROJECT GOAL

Design and create a prototype energy harvesting system to recharge and power an existing IoT sensor design used to perform condition-based maintenance in industrial railroad applications.

Condition-based maintenance (CBM) systems that use wireless sensors are becoming a popular and useful tool for identifying maintenance needs and preventing system failure. This project presents a vibration-based energy harvesting method to extend the IoT sensor battery life to around three to five years in a railroad operating environment.

The team developed an energy harvesting solution that captures vibrational and solar energy from the operating environment to recharge the IoT sensors in the CBM system. Piezoelectric generators capture the vibrational energy when vibrated at certain frequencies, and solar panels on the exterior of the system capture the solar energy. An onboard microcontroller monitors the incoming harvested energy and connects the source to the rest of the circuit when a certain voltage threshold is met. The battery charging circuit is equipped with a load sharing circuit, which allows power to be shared between the incoming power and battery to power the system.

TEAM MEMBERS

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Wyatt Pena

Subtle Sounds – Component Sound Analysis for Extracting and Analyzing Medical Information from Patient Encounters

Team 22047

Center for Accelerated Biomedical Innovation

PROJECT GOAL

Design and construct a system to record, save and analyze various sound components from patient encounters in a clinical setting.

Nearly 37 million people in the United States suffer from respiratory diseases such as asthma, chronic bronchitis and lung cancer. Physicians can't capture all sound that occurs during doctors' visits, so much of the nonverbal information from patient encounters is not extracted for further analysis.

The sound analysis system consists of three subsystems. A handheld device containing a digital stethoscope captures patient sounds using a Raspberry Pi Zero W, and a room audio capture system uses high-quality microphones to record the doctor-patient interaction. These two systems then transmit data to the third component: a server which analyzes and processes the recorded sound files using a Raspberry Pi4 and stores them securely within the clinic database. The system is equipped with various open-source codes using Python and MATLAB to extract and analyze sound components.

TEAM MEMBERS

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COLLEGE MENTOR

Elmer Grubbs

PROJECT ADVISORS

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CytoMech – Microfluidic System for Determination of Cell (Platelet) Stiffness

Team 22048

Center for Accelerated Biomedical Innovation

COLLEGE OF ENGINEERING Craig M. Berge Engineering Design Program

PROJECT GOAL

Design a compact and inexpensive system to measure the stiffness of individual platelets in a microfluidic chip using dielectrophoresis.

Blood clotting and related diseases account for the majority of hospitalizations and disease-related deaths in the United States, affecting more than 35 million people each year. By measuring the stiffness of platelets, medical researchers can create and refine implantable medical devices to reduce a patient's risk of developing these life-threatening conditions.

The CytoMech is a compact and cost-effective system to measure platelet stiffness. Platelets are suspended inside a microfluidic chip, imaged by a fluorescence-based microscope camera, and analyzed by the team's software system. The CytoMech uses a method known as dielectrophoresis to stretch platelets by subjecting them to a nonuniform electric field while the image analysis system measures the change in platelet size. Researchers can use a user-friendly graphical user interface to control the system, view the platelet while specifying the electrical force applied to it, and display the final result to the user. The system calculates the stiffness of the platelet based on the applied force and the deformation. By averaging the results of tests with multiple platelet samples, clinicians will be better able to evaluate the safety of implantable medical devices and diagnose a patient's risk for thrombosis.

TEAM MEMBERS

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PROJECT ADVISORS

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K - Dx – A Point-of-Care Potassium Diagnostic System

Team 22049

Center for Accelerated Biomedical Innovation

PROJECT GOAL

Estimate and directly measure potassium content of food and fluid using a portable potassium diagnostic system.

Kidneys are vital organs involved in the balance of fluids and electrolytes in the body. Intaking too little or too much potassium can have serious consequences on a person's health. For patients with chronic kidney disease, it is important to precisely moderate potassium intake. This project presents a portable potassium diagnostic system which can directly measure potassium content in food and fluid, as well as estimate potassium content through image recognition.

To directly measure potassium content, the system uses a probe which is placed into a food sample prepared using the system's homogenizer. A camera system then takes photos to identify and estimate the volume of the food or fluid. A Raspberry Pi computer contains both a software package with an evolving database listing potassium content for specific substances and a graphical user interface which allows users to easily track and record daily potassium intake. The recorded measurements are available for use by health care providers.

TEAM MEMBERS

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MicroDx – Point of Care Microparticle Detection System

Team 22050

Center for Accelerated Biomedical Innovation

PROJECT GOAL

Measure the size and concentration of PDMPs in a patient blood sample using dynamic light scattering.

Knowing platelet-dreived microparticle (PDMP) levels is important for proper treatment of patients with cardiac complications. Currently, determining a patient's PDMP levels is a lengthy process that requires expensive lab equipment. The team designed and developed a dynamic light scattering system as a cost effective, point-of-care alternative for sizing and quantifying PDMPs in a blood sample.

The design uses a 520 nm laser that shines through the buffy coat of a patient's blood sample. The PMDPs within the buffy coat interact with the beam to create light scatter that is captured by an avalanche photodiode. The intensity signal is read by an oscilloscope and processed by a Raspberry Pi to create a calibration curve using an autocorrelation function. These calibration curves are used to determine the size and quantify the PDMPs within the blood sample. A graphical user interface displays particle size and concentration. The Raspberry Pi saves and stores the optical analysis data for each run, and this data can be transferred to a separate device if desired. The entire system is housed in a dark, closed container that allows for sample access while ensuring a reliable environment for optical analysis.

TEAM MEMBERS

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WashBot
Team 22051

Center for Accelerated Biomedical Innovation

COLLEGE OF ENGINEERING Biomedical Engineering

PROJECT GOAL
Design an automatic hand washing machine with equal or superior cleaning capabilities to conventional hand washing.

Conventional hand washing involves touching multiple potentially contaminated surfaces. By minimizing the need to touch these surfaces, WashBot can reduce cross-contamination when handling raw meats and other foods or contaminants. In addition, the device reduces the amounts of water, soap and drying agents needed to wash hands.

The user begins by inserting their hands into the scrubbing chamber, where a sensor detects their hands and begins the pre-rinse and soaping stages, followed by a mechanical microfiber scrubbing phase. After scrubbing is complete, the user places their hands in a rinsing chamber for rinsing and drying. Multiple rinsing chambers are available to allow for either a quick rinse or a full wash, depending on the user's needs. An LCD screen displays the current stage of the washing cycle, as well as status of water quantity and system maintenance.

Water used during the pre-rinse and final rinse cycles is recycled to minimize water usage, with dirty, fresh and recycled water stored in separate tanks.

The team used the engineering design process to select commercial off-the-shelf (COTS) components and design, develop, integrate and test the COTS items, resulting in an effective system that saves water and decontaminates effectively.

TEAM MEMBERS
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Popcorn Processor
Team 22052

Tucson Village Farm

COLLEGE OF ENGINEERING Craig M. Berge Engineering Design Program

PROJECT GOAL
Create a system for washing and drying a large amount of popcorn kernels that can enhance educational efforts at Tucson Village Farm but is also able to run autonomously when needed.

Tucson Village Farm is an education-based farm for youth with a central educational theme of nutrition and healthy living. More than 15,000 children make visits annually and are provided with healthy snacks, including popcorn, which is grown on the farm.

Although kids assist with the harvesting, dekerneling, and washing of the popcorn, they cannot clean and dry all of it. Each year at harvest time, Tucson Village Farm experiences a bottleneck, with manual processing eating up many hundreds of hours of staff and volunteer time.

The team created the Popcorn Processor with the ability to run either autonomously or by human power.

The washer, similar to a laundry machine, uses a motor to spin an inner drum where kernels are thoroughly washed and chaff is removed to an outer drum. The washer can be powered by a stationary bicycle to provide a more interactive and educational experience for school groups. The dryer, similar to a chili roaster, uses a motor that spins the drum while a fan dries the kernels. The dryer also includes a hand crank for manual operation, again to enhance the educational experience. The system can clean and dry up to 5 pounds of kernels within a few minutes.

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PROJECT ADVISOR
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Adaptive Robot Gripper

Team 22053

Unilever

Center for Accelerated Biomedical Innovation

PROJECT GOAL

Develop an adaptive gripper system with a custom recognition system for a robot arm.

In the fast-moving consumer goods industry, manufacturers are motivated to increase the agility of their supply chains. This also means packing lines and packing machinery need to work with more complex product portfolios, without creating long periods of downtime between production runs. Adaptive robot grippers offer opportunities to minimize changeover time and increase agility of the equipment. These grippers can adapt to a range of product geometries and consistencies without mechanical modification.

This adaptive design is based on machine learning image recognition software, a sonar positioning system and a mechanical gripper. In addition, the team added emulation software based on RoboDK to deal with the technical challenges of sourcing a robot arm. A single Raspberry Pi computer runs the camera and gripper system. To keep the gripper from damaging objects, force feedback comes from a single sensor at the end of one side of the gripper. A sonar system determines the position of each object and feeds that into the Raspberry Pi to inform the gripper where to grab.

The mechanical gripper demonstrates the real-world use of the system, while the emulation software provides a comprehensive view into what implementation may look like on the factory floor.

TEAM MEMBERS

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Joe Liang, *Electrical & Computer Engineering*
Connor Nagore, *Mechanical Engineering*

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Don McDonald

PROJECT ADVISOR

Kati Gastrow

Renal Extremity Device to Measure Impedance, Edema and Movement

Team 22054

Center for Accelerated Biomedical Innovation

PROJECT GOAL

Design and build a wearable device that measures impedance, edema, and restless leg movement data, then display that data on a phone app for patients with chronic kidney disease.

Kidney or renal disease, leading to chronic kidney disease (CKD) and eventual end-stage renal disease (ESRD) is on the rise in the U.S., affecting 37 million people, or 15% of adults. Kidneys regulate the body's water and electrolyte balance and remove wastes and excess fluids to maintain homeostasis.

Patients afflicted with CKD and ESRD suffer from excess fluid retention and leg edema or swelling. Many of these patients also develop uncontrolled leg movement, known as restless leg syndrome (RLS). In dialysis, the standard therapy, a machine effectively functions as a kidney substitute, removing excess water and wastes. Despite the efficacy of dialysis, physicians are unable to determine a patient's baseline water content, or what is termed "dry weight" vs. water excess, making it unclear how to optimally time recurrent dialysis.

The team constructed a wearable lower leg band measurement device containing a single, four-electrode impedance-edema circuit and an accelerometer. A constant voltage and current is applied to the circuit to determine corresponding resistance values. With this impedance value, edema can be extrapolated using a simple mathematical model. The accelerometer detects movements associated with the motion of RLS. The device communicates data to a connected iOS app. This app displays the impedance, edema and RLS detection data for patients and physicians to view.

TEAM MEMBERS

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Surgical Instruments for Rapid Removal of Broken Screws and Time-Efficient Treatment of Bone Infections

Team 22055

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

Design and prototype three distinct orthopedic surgical instruments that will assist in the removal of cannulated screws, remove solid screws and aid in the removal of infected tissue.

Better instruments for orthopedic surgeons could shorten operating room times and improve surgical outcomes.

Cannulated screws only have threads at the end and can strip if the bone becomes infected or if too much torque is applied. The team designed a removal instrument that enables the surgeon to pull upward on the screw so that it engages uninfected bone and is then able to be unscrewed. The instrument's two parts consist of a thin rod with a hook that enters the hollow screw through a hole, attaching to its bottom, and a handle that connects to the other end of the rod. The hook had to easily catch the screw's end and fit through the screw, yet be strong enough to apply upward force without failing. The solid screw removal instrument is a unibody design consisting of a lever and a forked tip that encloses below the head of the buried screw. Pushing down on the lever raises the screw.

Orthopedic surgeons also need a more efficient method to remove infected tissue while simultaneously providing suction and irrigation. The team developed one instrument to perform all three functions by combining a curette, used for scaping tissue, with irrigation and suction systems. A unique design made the instrument easier to manufacture, and human ergonomics principles were incorporated into all the instruments to make them comfortable to use.

TEAM MEMBERS

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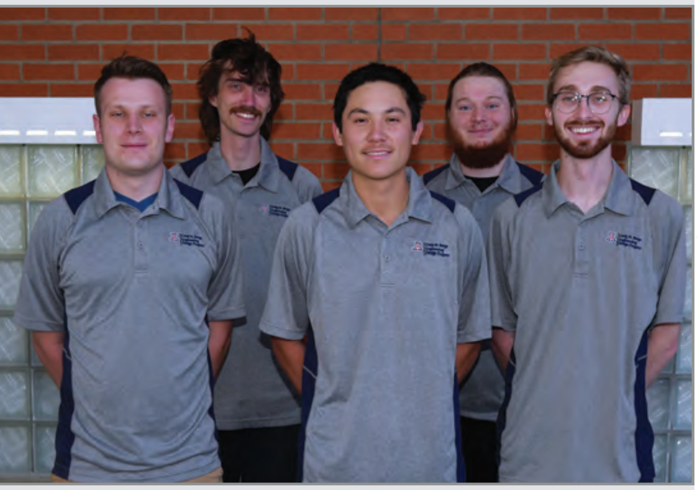

Windmill Conversion

Team 22057

Tucson Village Farm

COLLEGE OF ENGINEERING
Craig M. Berge Engineering Design Program

PROJECT GOAL

Convert an Aermotor 702 water pump windmill into a wind turbine to produce electricity and promote renewable energy.

The 33-foot-tall Aermotor 702 windmill outside of Tucson Village Farms serves as a beacon, welcoming visitors to the site. The windmill originally served as a naturally powered water pump, but the farm did not need this function. The team converted the windmill to produce electricity instead. It now performs the relevant function of generating renewable energy while also serving as an educational experience for visitors.

This conversion maximizes efficiency to harness energy from the wind while maintaining the aesthetic of the Aermotor 702. The team replaced the pump's mechanics in the nacelle with a custom drivetrain to rotate a Permanent Magnet Alternator, generating three-phase electrical power to reduce energy loss leading down the tower. A charge controller at the base stores the energy in a deep cycle gel battery and safely dissipates excess energy in the form of heat to prevent overcharging.

The team also designed an interactive exhibit where visitors can produce electricity with a hand-cranked generator and see their results with an LED wattmeter, along with monitors for live data displaying the wind speeds and power generated from the turbine. Visitors and volunteers can use the stored electricity to power their devices with USB and electrical outlets.

TEAM MEMBERS

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Michael Debbins, *Aerospace Engineering, Mechanical Engineering*
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PROJECT ADVISOR

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World's First Smart Fresh Outdoor Air Ventilation Fan

Team 22058

NATURE'S COOLING SYSTEMS PROJECT
CREATING URBAN HEAT SOLUTIONS

PROJECT GOAL

Develop the electronics, firmware, and a phone app to control the World's First Smart Fresh Outdoor Air Ventilation Fan.

This project creates a modern, energy-efficient approach to keeping air fresh and temperate within a home. This smart window fan system includes an app that allows users to monitor parameters and set personal preferences for using filtered outside air to intelligently ventilate, cool and heat.

The design uses extremely low power in an idle state, but can still exceed 250 cubic feet per minute of air flow when turned to full. It employs the ESP32 WiFi-enabled microcontroller, known as a sytem on a chip. When the internal sensor detects the temperature outside is cooler than the temperature inside, the fan pumps outside air through a MERV-8 air filter until the user's desired temperature is reached.

The team developed logic and firmware to ensure ventilatation occurs when the outdoor air temperature is cool – normally in late evening and early morning – and heating ventilation takes place when it's warmer, normally late afternoon.

The unit is also able to communicate with a WiFi-enabled air quality sensor, allowing the user to set a desired quality index without integrating costly components. Using the MQTT protocol, a standard messaging protocol for the Internet of Things, the ESP32 communicates with Amazon's web servers to allow control from the user's phone, including setting desired temperature and humidity levels. The user can also operate the fan through manual controls if desired.

TEAM MEMBERS

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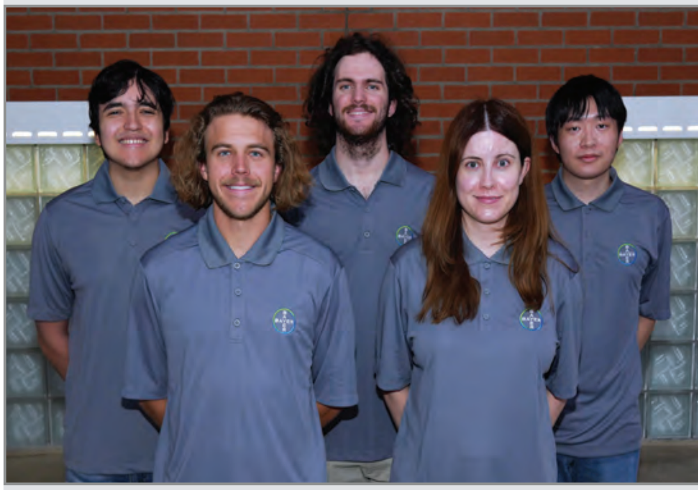
Sensible Solutions

Team 22059

Bayer CropScience



PROJECT GOAL

Design an imaging system that will analyze crops and provide a predictive measurement that can be used to trigger a corrective action prior to the crops exhibiting a stress.

Modern agriculture relies heavily on reactive farming, in which mitigatory actions are taken based on human observation of plant conditions. Advances in technology have begun to pave the way for predictive measurements in farming, but the technology is not yet commercially available.

Greenhouse technicians at Bayer Crop Science will use the imaging system developed by this team to access real-time data in analyzing growth factors that determine the readiness of each individual plant to move to the next stage of crop development.

The system design is centered around an Intel RealSense L515 camera capable of taking high-resolution RGB images as well as generating point particle cloud data using lidar, or Light Detection and Ranging, technology. The point particle cloud provides a three-dimensional representation of the target seedlings that is used to measure plant height with a high degree of accuracy.

A Raspberry Pi module controls the Intel camera calibration and data processing, which is outputted to an LCD touchscreen graphic user interface that allows Bayer staff to store, access and manipulate collected data.

The team developed a protective wooden frame surrounding the camera, mount and imaging area. The frame is mounted to the top of a utility cart to provide mobility and ease of access around Bayer's facility.

TEAM MEMBERS

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Spacecraft Torques and Forces Measurement System

Team 22060

GEOST

PROJECT GOAL

To measure the micro torques and forces of a satellite payload.

Measuring micro torques and forces is important for analyzing spacecraft components. Under the effect of Earth's gravitational forces, micro torques and forces cause negligible reaction when applied to an object. However, while in space these same forces can cause large reactionary motions. This team developed a system to isolate, measure and analyze the effects of a known torque and force generator. Performing these tests in one Earth gravity, or the amount of gravity at Earth's surface, predicts reactions of the system in space.

The design has three subsystems that use a combination of air-bearing components; an inertial measurement unit (IMU); linear actuators; and an electric motor to produce and measure the motion of the system. The team leveraged near frictionless air-bearing technology to levitate an onboard compressed air tank, a satellite bus to house measurement and data processing components, and the disturbance-generating payload.

The team designed a force generator that is driven by a microcontroller to output a known torque and force. This disturbance is measured by the IMU. IMU data is collected by a microcontroller and written to a removable data drive. The data is then transferred to an external computer, where software calculates the force and torque applied to the system.

TEAM MEMBERS

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Automated System for Measuring Ecosystem Gas Fluxes in Tropical Forests

Team 22061

Biosphere 2

PROJECT GOAL

Automate the measurement of tree stem gas fluxes and soil/water surface fluxes in the várzea rainforest.

Though the Amazon basin várzea forests have been estimated to emit more methane from the stems of their trees than all Arctic wetlands combined, integrated study of the controls, budget and seasonal dynamics of methane cycling in these great forests is lacking. Due to severe seasonal flooding, obtaining continuous gas-flux measurements has proven difficult, incentivizing the need for a continuous, automated system. The team designed, constructed and tested a system in the rainforest of Biosphere 2.

The system consists of two towers: one tower analyzes soil-water surface interfaces and the other measures tree-surface interfaces. This provides year-round monitoring and withstands up to 10 feet of flooding. Polyurethane foam in the towers floats along installed guide rails during floods for sensor measurements at three heights along a tree.

Each tower contains a chamber which is sealed against a surface by an actuator controlled by pressure sensors. Gas enclosed within the chamber is then pumped to a trace gas analyzer where concentrations of methane, carbon dioxide and water vapor are measured. The system is controlled by a master hub and a user controller which transmit data via radio transmission. The interconnected system allows researchers to take gas flux measurements 12 times a day at multiple locations year-round in rainforest environments.

TEAM MEMBERS

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Energy-Efficient Rolling/Flying Hybrid Robot
Team 22062

PROJECT GOAL

Design and prototype accouterments to a hybrid rolling/flying robot system including an outer shell, GUI, camera gimbal, center of gravity control system and a charging dock.

Revolute Robotics is pioneering an autonomous rolling/flying robot. This system will allow their robot to navigate various terrain, switching between a maneuverable flying mode and energy-efficient rolling mode. The goal of this project was to develop several assisting subsystems.

The aluminum rib shell design significantly reduces bouncing, improving the rolling operation of the robot and allowing for easy assembly and disassembly with common parts making maintenance and manufacturing simple. The delivered GUI provides an interface with the drone and offering data telemetry and command sending. The camera gimbal uses motors to rotate the robot's primary camera in two axes to maintain level pitch in both rolling and flying modes. The center of gravity control system further makes the changing orientation between rolling and flying more efficient and allows the drone to easily position itself for charging. The charging station uses wireless induction power transfer between custom wound coils. It is accessible from all directions and allows the robot to wirelessly charge its battery without an operator to plug it in or remove the robot from its shell.

TEAM MEMBERS

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Compact Near-Infrared Imaging Module for Photolithography Source Metrology
Team 22063

PROJECT GOAL

Complete design and analysis – optical, electrical and mechanical – of three new NIRIM designs that surpass the current design by reducing total system volume while maintaining or improving both mechanical and imaging optical requirements.

This team employed novel imaging and optomechanical architectures – including off-axis aspheres, freeforms and non-rotationally symmetric surfaces – in order to match or improve the optical performance of existing Near-Infrared Imager (NIRIM) designs while significantly reducing the overall volume.

ASML develops extreme ultraviolet (EUV) lithography light sources used in the manufacture of semiconductor chips. EUV generation takes place inside a large diameter – greater than 1.5 meter – chamber by vaporizing/ionizing small liquid tin droplets at high repetition rates using a powerful carbon dioxide laser. The vaporized/ionized tin droplets produce EUV radiation, which is collected by a mirror and focused into a lithographic scanner. The scanning system exposes lithographic patterns on semiconductor wafers using the EUV light. The function of the Compact NIRIM is to monitor the size, position, spatial stability and form factor of the stream of tin droplets as they traverse through its field of view.

Due to the extremely high cost, lead time and complexity of manufacturing custom optics, the team was only responsible for designing the optical system, its optomechanical mounts and enclosure dimensions within relevant software.

TEAM MEMBERS

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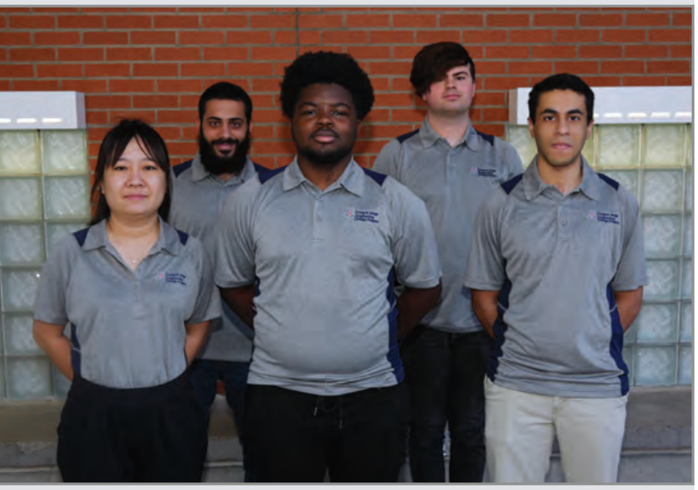

Solar Multiphaser Energy Converter

Team 22064

PROJECT GOAL

Maximize cost-effective power consumption by taking advantage of renewable energy sources and storing excess power in an electric vehicle battery for use or sale later.

Renewable energy power sources offer unpredictable, intermittent availability. As mobility technology becomes more electrified, electric vehicle ownership will increase. The renewable energy multiphase converter intelligently switches between energy sources to charge the electric vehicle battery and can sell excess power to the electrical grid when advantageous.

This new system has electric vehicle batteries with a combination of off-the-shelf hardware to monitor renewable energy availability and grid demand to determine the most cost-effective use of the power – charging and direct use or sale to the grid.

The team used a microcontroller-based single-board computer and developed software to manage the distribution of power between four systems – solar panels, wind generator, electric grid and the electric vehicle. The developed software measures the power output of each source, compares them, and sends a signal that triggers a relay system through the microcontroller to fulfill the users' needs, based on efficiency, cost reduction and/or profit.

TEAM MEMBERS

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Digital to Physical Point Mapping

Team 22065

PROJECT GOAL

Create a portable projection system which projects the installation locations for rigid test widgets onto a complex, nonlinear test surface.

Within a wide variety of fields, items – also known as widgets – must be located, bonded, attached or otherwise placed in precise positions on larger objects or assemblies. This is a time-consuming and expensive process. The digital to physical point mapping system provides a way to quickly find and display key points on an object, such as a car or building, allowing users to project locations where equipment must be placed.

This system can be used for positioning signs, accelerometers, or anything that requires accurate placement. The digital to physical point mapping system aims to make this process quicker and more efficient, as the process is accomplished by fewer employees.

The system consists of a physical mount which holds up to four cameras positioned in a single plane, one projector and QR code markers placed on an object. Additionally, the system integrates both unity and MATLAB code to determine the location of the object and create/distort images to correct for geometric distortions that pinpoint the key locations on the object.

TEAM MEMBERS

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Tyler Ray Wong, *Electrical & Computer Engineering*

COLLEGE MENTOR

Huy Le

PROJECT ADVISOR

Michael Futch

Miniature Robust On Board Recorder (MR-OBR)

Team 22066

Raytheon Technologies

PROJECT GOAL

Design a miniature recording device that is capable of recording changes in acceleration, shock and temperature and is robust enough to survive multiple uses in extreme environments.

Onboard recorders are mounted to test vehicles and characterize shock, vibration and temperature changes that the unit experiences under test experiences. However, some projects are unable to use the existing devices due to size or shape limitations. The MR-OBR is a device small enough to fit in the palm of a user's hand. The team designed it to compactly contain electrical components and withstand significant force.

The design consists of a small aluminum shell with an end cap to allow the user access to the inside of the recorder. The system is able to withstand up to 5,000 g's of acceleration and temperatures between -40 degrees Celsius and 85 degrees Celsius. The team used lightweight 7075 aluminum alloy to meet survivability criteria. Internally, the device contains two stacked printed circuit boards responsible for sensing and recording environmental changes. The circuit consists of a microcontroller, two accelerometers, a temperature sensor and an SD card reader for storage. When the cap is removed, the user will be able to access recorded data and change the battery if necessary.

TEAM MEMBERS

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Adaptation of a Small Tactical Unmanned Aircraft

Team 22067

BLACKBAR AMERICAN MADE

PROJECT GOAL

Integrate vertical takeoff and landing capabilities onto a preexisting UAV, while keeping the same footprint of the original aircraft.

UAVs are widely used in many applications, including search and rescue, mapping and surveying, surveillance, and payload transportation, among others. While fixed-wing UAVs can successfully fulfill these tasks, many of them require a large amount of space for takeoffs and landings.

The team converted a preexisting small airframe to have vertical takeoff and landing capabilities. This UAV offers the benefits of other fixed-wing vehicles but can accomplish tasks discreetly and without requiring the extra space necessary for most fixed-wing aircrafts.

In order to effectively integrate vertical takeoff and landing capabilities, the team added four additional motors onto the existing airframe in a quadrangle design, providing aircraft stability on its vertical axis as well as keeping aerodynamics similar to the original fixed wing UAV. This was accomplished while keeping the same footprint as the original aircraft.

TEAM MEMBERS

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PROJECT ADVISOR

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Close-Range High-Speed Video Tracking

Team 22068

Raytheon Technologies

PROJECT GOAL

Develop and deliver a motorized optical device that is capable of tracking a high-speed object moving at up to 1,000 feet per second.

High-speed object tracking solutions exist at high price points. Tracking high-speed objects at close range with high-speed video equipment is nontrivial due to the high angular rate of motion required. This project presents a low-cost method for tracking high-speed objects by reducing the mass of a rotating assembly through the incorporation of a large scanning mirror and a stationary camera.

The design uses a combination of custom and commercial off-the-shelf hardware and software components packaged in a robust manner that can be used outdoors in conjunction with external high-speed video equipment to capture detailed video of dynamic events. The team designed and built a custom motor-controlled structure that controls the scanning mirror in both azimuth and elevation. This ensures that the object can be imaged by the high-speed camera at all times.

TEAM MEMBERS

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COLLEGE MENTOR

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Smart Rocks - A Network of Covert Smart Sensors (Joint UA-UMass Project)

Team 22069

Raytheon Technologies

PROJECT GOAL

Develop a network of covert smart sensors to detect and record a variety of environmental events.

A variety of commercial sensors on the market provide wireless transmission; however, no wireless, modular, multi-sensor units are capable of mesh networking. Satellites and other heavy-duty sensor-based equipment have the ability to collect data from non-surveillance areas, but are limited in resolution due to their distance and profile.

This team, in conjunction with the University of Massachusetts Lowell, designed a self-powered, autonomous system that provides a network of covert sensors in the form of rocks. This system is suitable for wildlife, military and security applications in which area monitoring must be completed in a discreet manner.

Smart Rocks are capable of sensing temperature, acoustics, and motion, and of storing data while interfacing with other rocks, or nodes. These rocks are capable of connecting to an external network for data transfer. Network functionality is maintained in the event of a single node failure. The Smart Rocks project provides a modern approach to wide area surveillance that is autonomous, low cost and user-friendly.

TEAM MEMBERS

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Pat Caldwell

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Scott Fiore

Scrap and Rebuild and Overhaul Reduction

Team 22070

Celestica

PROJECT GOAL

Identify main drivers of rework and scrap during production assembly and apply root cause analysis tools in a growing aerospace contract manufacturing company.

In manufacturing, scrap and rework add cost to finished products and affect delivery commitments. If companies understand the root causes of failures that result in scrap and rework, they can correct the problems.

This project used historic manufacturing data to analyze and identify the finished products and subassemblies causing the most scrap and rework.

The team identified the main drivers of rework and scrap using the 80/20 Pareto Principle, which states that for many outcomes, roughly 80% of consequences result from 20% of causes. The team employed MS Excel data analysis tools, including pivot tables and sorting. and constructed a complex three-level Pareto chart to identify the main components that cause rework across four different manufacturing cells. These levels break down to a specific component in the manufacturing where failures occur. They conducted a root cause analysis using Ishikawa Diagrams, also known as fishbone or cause-and-effect diagrams, along with the 5 Whys problem-solving technique, to distinguish potential causes of rework. The team's analysis highlights specific areas that require improvement, facilitating production engineering efforts for root causes of rejections and pointing toward corrective actions.

TEAM MEMBERS

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Chris Nagel

The Mobile Vertical Farm (or Go-Vertical Farm) for Automation of Vertical Farming Operations

Team 22071

COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING
Biosystems Engineering

PROJECT GOAL

Automate vertical farming for the production of leafy greens at a modular scale.

The human population is estimated to reach 10 billion by the year 2050. The challenge is finding a way to sustainably feed a global population that large. Controlled environment agriculture practices such as greenhouse growing, hydroponics and vertical farming offer solutions to generate more produce with a smaller footprint. However, indoor vertical farms have a high labor cost, which has driven an interest in automation. The Life Grow Bot (LGBot) is an autonomous industrial robot with a hydroponic growing tower incorporated on top of it. The LGBot maintains all functions for growing leafy greens, including transportation around the warehouse from planting until harvest. The LGBot presents a possible method of growing leafy vegetables as part of an autonomous production system.

The LGBot consists of a Raspberry Pi controlled autonomous robot that uses ultrasonic and lidar, or Light Detection and Ranging, sensors to navigate through an indoor environment. The LGBot is designed to detect and avoid obstacles in addition to docking with its complementary Growth Recharge Station. The top part of the LGBot is a three-tiered hydroponic vertical farm. When the LGBot is docked to the Growth Recharge Station, a recirculating nutrient solution and optimized supplemental lighting provide the growing environment for a variety of leafy vegetables. The LGBot communicates with a graphical user interface, which in addition to displaying the location of the unit in the indoor environment, can communicate simple commands to the LGBot. LGBot reduces the cost of growing leafy greens by eliminating the need for any human interface for the complete growing cycle.

TEAM MEMBERS

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Joel L Cuello

Intelligent Aeroponic Microgravity & Earth Nutrient Delivery (I-AMEND) System for Bioregenerative Space Life Support and Earth Applications

Team 22072

COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING
Biosystems Engineering

PROJECT GOAL

Design and build an aeroponic nutrient delivery system that will enable the productive growth of crops in microgravity and other extraterrestrial environments.

Growing crops in space is imperative to the advancement of space travel. A promising technique for this is aeroponics, which optimizes space and water compared to traditional cultivation techniques. This system will allow astronauts to control which solutions are interacting with the plants while in turn providing key nutrients and calories.

The I-AMEND System consists of a combination of mechanical components, electronics and biosystem techniques to emit water, nutrients and air along a crop row. The team developed an autonomous, controllable system that supports onboard sensors, cameras and moving emitters which can gently flow horizontally through the system. A Raspberry Pi allows the user to adjust the emitters' positions via a mounted touch screen. Sensor data and camera footage are collected and accessible for informed environmental control and crop growth optimization. Designed to work in varying gravity environments, this system will help make long-term missions to the moon and Mars more feasible.

TEAM MEMBERS

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Development of a Tool for Calculating Airport Noise Contours From Noise Monitoring Equipment

Team 22073

Gary Wonacott

PROJECT GOAL

Create a website that displays noise contours created with data collected with noise monitoring equipment.

People living near airports are constantly exposed to high levels of noise. Currently, noise contour maps are computed by airport facilities using the Aviation Environmental Design Tool (AEDT). This project presents a tool that calculates noise contours using manually collected noise data, beginning with Tucson International Airport.

The design of the project includes three major modules:

- the creation of a tool – in this case, a website;
- the collection of data at Tucson International Airport;
- a methodology for the creation of noise contours.

The website is for people who reside near airport facilities and are affected by the high noise levels created by airplanes. The website provides the public with deeper insight, knowledge and material regarding noise levels within their area. It further allows them to submit noise complaints as well as the ability to view descriptions regarding the noise levels around the area they wish to observe. The data collected with the noise monitor is interpolated in order to create noise contour lines.

TEAM MEMBERS

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Elmer Grubbs

PROJECT ADVISOR

Gary Wonacott

High Purity Rare Earth Separation

Team 22074

REX Medical Services, LLC

PROJECT GOAL

Reclaim rare earth metals that are byproducts of aerospace industrial processes using non-hazardous methods while preventing these metals from entering the waste stream.

The High Purity Rare Earth Separation project focuses on recycling materials that are a byproduct of aerospace industry manufacturing processes, reducing the industry's dependence on foreign sources. The most important materials in this project are zirconia, a transition metal oxide, and yttria, a rare earth oxide.

Many aerospace companies create their parts using molds. Yttria composes the innermost layers, and zirconia makes up the remaining layers of the shell. The team's primary goal was to separate the zirconia and yttria from each other using physical processes rather than chemical processes and prevent the materials from being sent to landfills.

Using a physical process as opposed to a chemical process is beneficial because it doesn't rely on damaging and dangerous chemicals that can pollute water and soil and harm animals by increasing acidity and other toxins in an environment. This team researched and designed novel physical processes that use existing technology to separate the materials for future reuse. Using these processes will allow foundries to run more independently, without relying on imports and without constantly purchasing expensive elements such as zirconium and yttrium.

TEAM MEMBERS

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Senior Metallic Mine Design Competition

Team 22076

COLLEGE OF ENGINEERING
Mining & Geological Engineering

PROJECT GOAL

Design and propose a feasible mine plan for a metallic mineral deposit based on real-world constraints provided by the SME Metallic Mine Design Competition.

Six mining engineering students participated in an international collegiate competition requiring teams to create a mine plan and evaluate its feasibility using real-world data. The contest was administered by the Society for Mining, Metallurgy & Exploration.

In Phase 1 of the competition, the team designed a metal mine based on a given resource model, processing data and equipment restrictions. The final design considered multiple economic, environmental, equipment, processing and risk tradeoffs to determine the best plan. The results were compiled into a report and presented to the judges.

Phase 2 consisted of updating the mine design under additional constraints. Finally, the plan was reported at the MINEXCHANGE 2022 conference in Salt Lake City, Utah.

Ultimately, the team placed second in the worldwide competition.

TEAM MEMBERS

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Brad Ross

Sustainable Lithium Production

Team 22077

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Develop a high-efficiency battery recycling facility to provide reuse for end-of-life lithium products, creating lithium carbonate and other valuable metal salts used in conjunction with direct recycling and battery manufacturing.

Lithium-ion batteries are rapidly becoming the primary form of commercial energy storage, but the United States contains less than 0.5% of the Earth's known lithium supply. Recycling of these products is vital to provide a dependable and sustainable source of lithium for the growing renewable energy economy.

The design employs a lithium-ion battery recycling process that recovers more than 95% of valuable materials, resulting in lower emissions and energy usage than competing methods. The team developed a breakdown method through controlled-atmosphere shredding under carbdon dioxide and separating to increase throughput. Metal ions from the batteries' cathodes are removed through chemical leaching. From the ionic solution, cobalt, lithium, nickel and manganese are isolated and ready for reuse in battery manufacturing.

TEAM MEMBERS

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Alcoholic Beverages From Excess Biomass of Date Production

Team 22078

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Produce a high-quality alcoholic date beverage through an efficient process, using excess biomass from date production.

The Bard Valley Natural Delight date company produces around 30 million pounds of dates each year. However, date production also generates excess biomass that gets thrown away. The company wanted an economical use of these dates that would otherwise go to waste.

Fruit wine has been made since the beginning of civilization, and today it is a growing market. The team designed a process for fruit wine that starts with both pureed and whole dates. Tartaric acid and ICV Okay yeast were added to a fermentation keg to begin the alcohol production. The chemical process uses the yeast to break down sugar, producing ethyl alcohol and carbon dioxide. After the fermentation has ended with the desired alcohol by volume (ABV), the wine is strained and cooled with a chilling coil. The final product is a dessert wine with 15% to 20% ABV.

TEAM MEMBERS

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Environmental Engineering Soil Laboratory

Team 22079

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Create a soil laboratory that demonstrates a property or remediation technique for soil to environmental engineering students.

Soil vapor extraction is a useful remediation technique for soil that has been contaminated with dangerous, volatile organics. The process applies a vacuum to the soil that creates an airflow to remove the unwanted elements. The team designed a lab to demonstrate this transport phenomenon on a smaller, controlled scale to students.

In the lab, soil is purposefully contaminated with small amounts of toluene. The soil is then deposited into several extraction vessels. These vessels are attached to a vacuum system that creates airflow through them, removing the contamination. The toluene is then delivered to an activated carbon filter for disposal. Individual extraction vessels are taken out of the system on set time intervals for analysis. The remediated soil then goes through a liquid extraction process where a small amount of hexane is added to extract the remaining toluene. Finally, the concentration of toluene is measured via gas chromatography/flame ionization detector analysis. This gives the students data to model the extraction process.

TEAM MEMBERS

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Gregory Ogden

PFAS Unit Process Wastewater Treatment Proposal

Team 22080

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Design an optimized wastewater treatment unit process capable of PFAS removal to the EPA advised concentration of 70 ppt.

Per-/polyfluorinated alkyl substances (PFAS) are a family of contaminants causing growing concern. They are used in many industries and consumer goods because of their compound stability and hydrophobic, oleophobic and hydrophilic functionalities. But research suggests that exposure to PFAS can be harmful to health. This project uses a tertiary wastewater unit process to remove PFAS via adsorption to granular activated carbon (GAC).

The design consists of GAC adsorption columns, placed in parallel and lead-lag configuration to reduce the flow rate and increase the wastewater's contact time without drastically increasing the overall retention time. The team conducted an experiment to determine the breakthrough properties of GAC with the PFAS in order to improve modeling of the process. The improved model allowed for a more accurate prediction of compound removal and GAC replacement requirements. The design effectively adsorbs the PFAS compounds and produces clean effluent water with a concentration safely below the recommended EPA standard of 70 ppt.

TEAM MEMBERS

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Economic Conversion of Date Pits Into Oils for Cosmetics

Team 22081

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Create a process, using SC-CO2, that extracts at least 95% of the oil available in discarded date pits for use in cosmetics.

The date pit is an economic waste product generated as a byproduct of date fruit production. These seeds contain antioxidants such as carotenoids, polyphenols and tannins, along with unsaturated fatty acids such as oleic and linoleic acids, that keep hair, skin and nails healthy.

The team developed a process to extract about 95% of the available seed oil using supercritical carbon dioxide (SC-CO2). Gaseous carbon dioxide is heated and compressed to supercritical conditions, then pumped to an extracting vessel containing ground date pits. The SC-CO2 extracts the oil from the pits and is then separated from the oil with a pressure reduction valve. A flash drum pressure drop removes the remaining carbon dioxide from the oil. The carbon dioxide is recycled back into the process after separation. The resulting date seed oil is more than 95% pure due to the efficiency of the separation process.

TEAM MEMBERS

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High Purity Separation of a Rare Earth Metal Aggregate

Team 22082

REX Medical Services, LLC

PROJECT GOAL

Determine the feasibility of mechanical or low-acid-use separation processes to recycle high purity yttria, a rare earth metal, and zirconia from a waste aggregate currently being stored within a landfill.

The physical and chemical characteristics of a substance provide valuable insight into the effectiveness that various separation processes will have in isolating it from a mixture. Determining properties like the magnetic susceptibility, density and solubility of a substance is the basis for developing a process that effectively purifies the desired products.

The team conducted experiments to establish the feasibility of separating and purifying the components of a waste aggregate using various physical and acid-conscious separation techniques. Physical separation processes can be highly effective methods for recovering valuable resources from discarded aggregate and are dependent on the physical properties of each component. Magnetic susceptibility, density separation, froth flotation and solubility were investigated as possible separation processes for the desirable components of the waste aggregate.

TEAM MEMBERS

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Water Filtration System for Heavy Metal and Bacterial Removal on the Navajo Nation

Team 22083

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Develop a cost-effective point-of-use water filtration unit for residents of the Navajo Nation.

Due to the lack of existing public water infrastructure, uranium and arsenic concentrations in drinking water pose a variety of health risks to the Navajo people. The unregulated water sources are often contaminated with bacteria as well. This project aims to provide a water filtration unit capable of reducing uranium, arsenic and coliform bacteria below the limits set by the EPA.

The filtration system consists of an adsorption column with packed beds of chitosan and granular activated carbon. The system's pump is powered by a battery that is charged by a stationary bicycle. The team created a prototype of the unit, as well as synthetic water representative of the region's groundwater chemistry, to test adsorption capacity for heavy metals and the lifespan of chitosan. The project applied principles of fluid mechanics and mass transfer operations to optimize filtration efficiency and energy consumption.The unit complies with EPA and tribal laws for potable water and hazardous waste disposal.

TEAM MEMBERS

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Harry Patton

Protein Bars Supplemented With Extracted Mealworm Protein

Team 22084

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Develop and optimize a process to create nutrition bars derived from protein-rich insects to provide an environmentally sustainable protein source for the current market.

Animal husbandry for food production has become an environmental concern due to the high consumption of scarce resources such as land, water and energy. Entomophagy, the practice of eating insects, is a growing area of study for its potential to help alleviate this food crisis. So the team developed a process to make a nutrition bar supplemented with mealworm protein.

Current products on the market generally use insects that are ground into a flour. Instead, the team determined a process for chemically extracting fat and protein from the mealworms. Experimentation determined the optimal conditions for the extraction while minimizing product waste. The fat was first separated using food-grade ethanol as an organic solvent. Then, protein was extracted through pH manipulation using sodium hydroxide and hydrochloric acid. The overall process was optimized by maximizing recycled utilities and raw materials to reduce waste, energy and cost.

TEAM MEMBERS

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Suchol Savagatrup

Proton Exchange Polynorbornyl Membrane for a Fuel Cell

Team 22085

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Chemically modify a preexisting polynorbornyl anion exchange membrane into a PEM that can operate at greater temperature ranges and is unaffected by the presence of water.

This proton exchange membrane (PEM) can be used in fuel cell applications, efficiently providing clean electricity to power items like cars, houses and generators. Fuel cells, along with other electrochemical devices, rely on the electrolyte inside to transfer a charge. By improving the electrolyte's ability to operate at higher temperatures – up to 200 degrees Celsius – and with minimal external systems, higher conduction rates can be realized.

This functionalization process was developed in the laboratory with small-scale fuel cell testing. The team created a series of chemical baths for the PEM which facilitate amine-phosphate reactions within the polymer that allow for optimal proton conduction rates. The conduction rate was obtained by measuring current and voltage production from the experimental fuel cell using PowerSuite software. The experimental findings were applied to an industrial scale to develop a process that produces $382m^2$ of functionalized PEM a year.

TEAM MEMBERS

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Dominic Gervasio

PROJECT ADVISOR

Dominic Gervasio

Saving Energy for Red River Biorefinery

Team 22086

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Use design of experiments techniques to help the Red River Biorefinery ethanol plant improve the efficiency of its distillation system.

The distillation system at Red River Biorefinery has issues with its anhydrous ethanol production rate and energy consumption. Using design of experiments techniques, the team ran the system through ASPEN and Minitab software to find optimal ways to improve the system. These methods helped find and analyze potential changes that could reduce energy usage and increase product output, while keeping modification cost minimal.

The analysis showed that changing the reflux ratio, feed temperature, operating temperature and pressure improved efficiency by increasing the production rate of anhydrous ethanol. The team also found that changing the feed temperature and reflux ratio had the largest impact on increasing production, while maintaining its purity and lowering energy consumption.

TEAM MEMBERS

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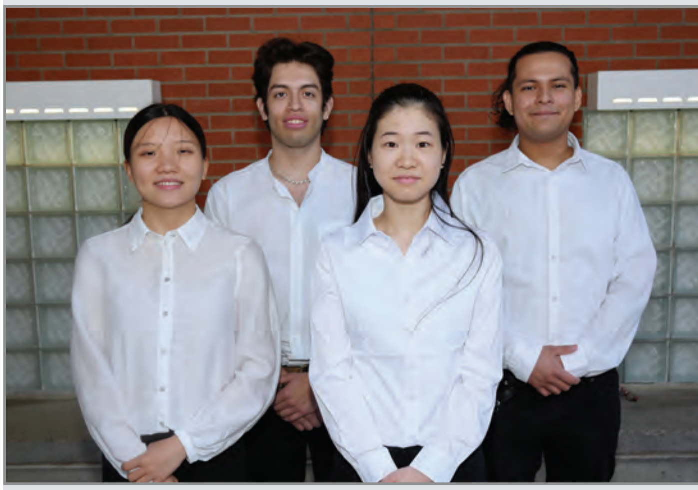
Methanol Production via Bi-Reformation of Methane Followed by Fischer-Tropsch Synthesis

Team 22087

College of Engineering Chemical & Environmental Engineering



PROJECT GOAL

Design, develop and optimize a process to produce methanol via the bi-reforming of methane, followed by a Fischer-Tropsch synthesis of the resulting syngas.

Natural gas is primarily methane, a greenhouse gas that is harmful to the environment. The team designed a process to synthesize natural gas into the useful – and much less harmful – substance, methanol. This is created via the bi-reforming of methane followed by a Fisher-Tropsch (FT) synthesis. The process could be applied at any landfill or livestock area producing methane. More in-depth analysis was done for large-scale production in partnership with a local fueling station in Fort Worth, Texas.

The process uses steam methane reformation and dry methane reformation processes running in parallel, with their respective product streams merged before being sent to the Fisher-Tropsch synthesis. This produces syngas with a hydrogen/carbon monoxide molar ratio closer to 2:1, the optimal feed stream to the Fischer-Tropsch gas-to-liquid synthesis. Optimized nickel-based and iron-based catalysts were used to increase the methanol production and make the process more economically sustainable.

TEAM MEMBERS

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COLLEGE MENTOR

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Optimization of Cave Creek Wastewater Treatment Plant

Team 22088

College of Engineering Chemical & Environmental Engineering

PROJECT GOAL

Optimize the Cave Creek wastewater treatment plant and incorporate innovative ideas to increase efficiency of the plant, comply with environmental regulations, and benefit the surrounding community.

Wastewater treatment is becoming an increasingly important field with population growth, drought and the looming effects of climate change. Due to these emerging issues, it is imperative to treat our water effectively, in order to reduce our reliance on natural sources.

The team used traditional elements of wastewater treatment, along with creative design, to effectively clean the water. Due to the high number of farms and golf courses in the Cave Creek area, it was also important to cater to these interests of the community. The design of the treament plant, which adheres to the state of Arizona's quality standards, was done primarily with Biowin and Microsoft Visio software.

TEAM MEMBERS

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Alkylation Unit

Team 22089

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Replace the MTBE system at a Gulf Coast refinery with another alkylation technology that meets all current EPA and federal regulations.

A gasoline refinery in the Gulf Coast area produces 130,000 barrels per stream day of regular 87 octane and 93 premium grades. It originally used a methyl tert-butyl ether (MTBE) system as its means of alkylation. However, the use of MTBE has been phased out in the United States due to its damaging effects to the environment.

The team designed a replacement unit with a solid-acid catalyst as the means of alkylation. Solid phosphoric acid is used because it is the least harmful for the environment and handling. This technology achieved the high octane yield necessary for gasoline production. Current market behavior analysis was incorporated to maximize profit by selectively choosing the amount of each grade to produce. The design uses distillation towers for separation, heat exchangers to achieve operating conditions, and pumps to deliver material at desired rates. Simulation tools were used to quantify the process based on its thermodynamic and mass transfer properties.

TEAM MEMBERS

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Fred Brinker

Liquified Natural Gas Receiving Terminal

Team 22090

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Design a profitable, liquefied natural gas receiving terminal on the East Coast. It must offload the fuel from tanker into storage and supply re-gasified natural gas to the distribution pipeline at a variable send-out rate.

As the United States moves toward cleaner energy while facing growing energy demands, natural gas is growing in popularity. Liquefied natural gas (LNG) is easily transportable by tanker and can travel to places where pipelines cannot. This team designed an LNG receiving terminal in Massachusetts.

The terminal receives regular tanker shipments of LNG into a pair of large full-containment cryogenic storage tanks. These tanks have a secondary containment chamber to prevent leaks and spills, while maintaining the very low operating temperature. Boil-off gas from the tanks is compressed and used to fuel the vaporizing system. The re-gasification system uses a submerged combustion vaporizer which is heated by burning a small fraction of the facility's natural gas. The gaseous natural gas is then sent to the pipeline for distribution. The terminal is designed to have an adjustable send-out rate to account for seasonal demand changes.

TEAM MEMBERS

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Hydro-Desulfurization Unit

Team 22091

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Chemical & Environmental Engineering

PROJECT GOAL

Design a process that removes sulfur from a blend of straight run gas oil and light cycle oil to produce an on-road diesel fuel with a maximum sulfur content of 0.005% by weight.

Removing sulfur from fossil fuels is necessary before being sold for on-road usage. When sulfur makes its way into the final fuel product, it turns into sulfur dioxide after combustion and releases into the atmosphere. This leads to environmental effects such as acid rain, haze and potential respiratory issues in humans and animals. Additionally, sulfur in diesel fuel can ruin the effectiveness of catalytic converters.

The team designed a catalytic hydro-desulfurization unit that processes 30,000 barrels per stream day of a blended straight run gas oil and light cycle oil feed. This produces an on-road diesel fuel that has a maximum sulfur content of 0.005% by weight, meeting necessary diesel fuel oil standards.

The hydrogen sulfide generated is converted to elemental sulfur or sulfuric acid and then sold. Elemental sulfur is vital in the fertilizer industry and agricultural processes. And sulfuric acid is used by many large-scale manufacturing plants.

TEAM MEMBERS

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Terrain Exploration Analysis Machine

Team 22093

PROJECT GOAL

Design a robot capable of navigating extreme lunar terrain, collecting data and placing equipment to assist the Artemis astronauts with their missions.

The rover design is equipped with sensors and cameras that allow it to create 3D maps of the lunar surface, take pictures of the regolith and record solar radiation data.

The design uses a Raspberry Pi to store data and manage the onboard instruments. The robot has four legs to navigate the steep and rugged terrain. The tail is a linear actuator that can extend and retract to act as a fifth point of contact for the rover or change the robot's center of gravity. The tail has an additional two motors that allow it to adjust its orientation. The arm has five motors that are used to maneuver equipment and any objects that block the robot's path.

The team produced a prototype from 3D-printed components and easily obtainable electronics. This model tested the robot's ability to walk, balance and navigate difficult terrain.

TEAM MEMBERS

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Gatlan Jon Nail, *Aerospace Engineering*
Jaxon Richards, *Aerospace Engineering*
David Michael Tousley, *Aerospace Engineering*

COLLEGE MENTOR

Jekan Thangavelauthum

PROJECT ADVISOR

Jekan Thangavelauthum

AIAA Design/Build/Fly 2022

Team 22094

COLLEGE OF ENGINEERING
Craig M. Berge Engineering Design Program

PROJECT GOAL

Optimize and build a cargo plane that meets the design and function requirements for this year's AIAA Design/Build/Fly competition.

The design team developed a remote-controlled airplane for the 2022 American Institute of Aeronautics and Astronautics (AIAA) Design/Build/Fly competition. The competition consists of three humanitarian missions to deliver vaccine vials and care packages to remote locations with unfavorable terrain. The team designed and optimized their aircraft to perform short takeoffs and landings with large payloads. This was accomplished using general engineering principles and the latest software available.

The airplane features a tapered wing mounted in a high-wing configuration that accommodates a single motor on the nose along with a payload dropping mechanism strategically placed at the center of gravity to maximize stability and control. Many iterations were performed to improve the model through analysis, prototyping and flight testing.

TEAM MEMBERS

Ben Matthew Ackmann, *Aerospace Engineering*
Carson Lane Bayze, *Aerospace Engineering*
Camden Jiovanni Castellano, *Aerospace Engineering*
Sheldon Curley, *Aerospace Engineering*
Francisco Oros, *Aerospace Engineering*
Maddie Schiffler, *Aerospace Engineering*

COLLEGE MENTOR

Sergey Shkarayev

PROJECT ADVISOR

Sergey Shkarayev

Long Term Surveillance via Solar-Powered UAV

Team 22095

PROJECT GOAL

Create a UAV that, once airborne, is able to harvest enough energy through wing-mounted solar cells to power itself for long-term operations, while simultaneously providing surveillance footage from an onboard camera.

Team Sky High designed an affordable, fully autonomous, solar-powered UAV capable of one month flight time at an altitude of 10,000 feet or higher. The UAV boasts a 40-megapixel camera and a communications bandwidth of 256 kilobits per second or greater, plus GPS tracking and telemetry capabilities.

The full-scale model has a wingspan of 12 meters and a chord length of 0.5 meters, with an overall mass estimate of 50 kg. The prototype scale is 25% of the full-scale model with a mass of approximately 12.5 kg. Flying at a speed of 13 meters per second, the UAV can complete 15 orbits of a 500-meter radius circle of operation in one hour.

TEAM MEMBERS

Chase Michael Chocek, *Aerospace Engineering*
Jackson L Dahl, *Aerospace Engineering*
Omar Fuerte, *Aerospace Engineering*
Cooper James McCoy, *Aerospace Engineering*
Jeffrey Scott Northcutt, *Aerospace Engineering*
James Roddel, *Aerospace Engineering*

COLLEGE MENTOR

Sergey Shkarayev

PROJECT ADVISOR

Sergey Shkarayev

Lunar Arachnid Surveillance and Exploration Rover

Team 22096

PROJECT GOAL

Develop a fully functioning rover that is capable of traveling over rough terrain using a new maneuverability technique.

The traditional wheel is insufficient when it comes to maneuvering over extreme lunar terrain, such as craters, icy and regolith surfaces, and large boulders. The fully functioning Lunar Arachnid Surveillance and Exploration Rover uses a new style of mobility. The rover uses individual legs equipped with rounded footings that ensure surface contact at all times, without sinking into the surface.

The prototype was scaled down to 43% of full size, with 3D-printed PLA/PETG plastic used for the body and legs. The servo motors move the legs back and forth, as well as up and down, giving a synchronized motion when all six hips are in synch. With the help of the onboard inertial measurement unit and remote control, the rover is able to navigate to a desired location, where it will use its infrared camera to search for ice in lunar craters.

TEAM MEMBERS

Matt Joseph Butler, *Aerospace Engineering*
Jonathan Capel, *Aerospace Engineering*
Derek Gilbert, *Aerospace Engineering*
Gray Hardy, *Aerospace Engineering*
Nicolas Kapler, *Aerospace Engineering, Mechanical Engineering*
Justin Lamb, *Aerospace Engineering*
Simon Quang Minh Ly, *Aerospace Engineering, Mechanical Engineering*
Manju Singh Espana, *Aerospace Engineering*

COLLEGE MENTOR

Jekan Thangavelauthum

PROJECT ADVISOR

Jekan Thangavelauthum

High-Altitude Surveillance and Reconnaissance Vehicle

Team 22097

PROJECT GOAL

Research methods to increase the endurance of high-altitude solar-powered UAVs.

The team researched the optimization of flight paths for solar panel performance at high altitude and designed a vehicle to meet the following requirements: achieve completely autonomous flight with human oversight and GPS tracking; be completely solar-powered with battery backups for emergency situations; remain within a 500-meter radius airspace; have a constant flight period of one month; maintain a steady altitude of 10,000 feet to 12,000 feet; operate a 40+ megapixel camera; and have a minimum communications bandwidth of 256 Kbps.

Further endurance benefits were analyzed by changing the release mechanisms to ensure quicker stability response. Static and dynamic stability were optimized for increased endurance.

TEAM MEMBERS

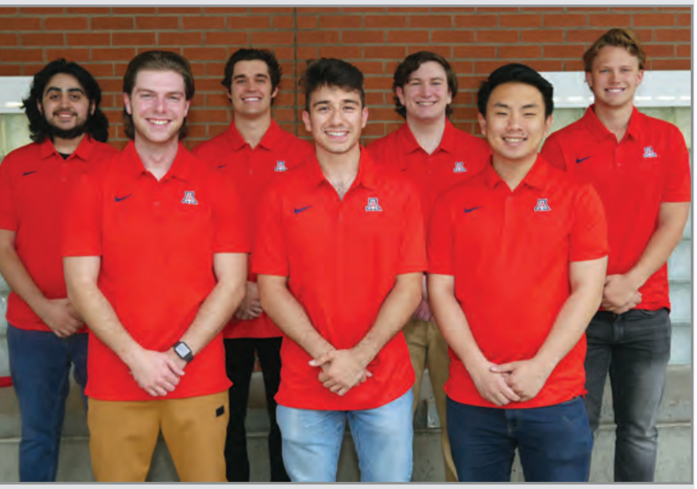
Bruce Bai, *Aerospace Engineering*
Darynn Peter Eggert, *Aerospace Engineering, Mechanical Engineering*
Martin Grant, *Aerospace Engineering*
Daniel David Kaitel, *Aerospace Engineering*
Steven Lingle, *Aerospace Engineering*
Carlos Humberto Montiel, *Aerospace Engineering*
Andrew Thomas Reynolds, *Aerospace Engineering*
Haoming Yan, *Aerospace Engineering*

COLLEGE MENTOR

Sergey Shkarayev

PROJECT ADVISOR

Sergey Shkarayev



Portable Utility Pallet

Team 22098

PROJECT GOAL

Develop a portable utility pallet for use at the lunar south pole.

The moon is an important stepping stone as humankind expands past the boundary of Earth's atmosphere. A portable utility pallet (PUP) that harnesses solar energy and distributes it via charging ports will be an integral piece of infrastructure for lunar missions of the near future. This robust PUP design can withstand harsh cosmic conditions and provide consistent power.

The team developed the 1/6-scale PUP prototype with aluminum panels forming the body of the model. Inside the panels, a microcontroller is wired to various servo motors. Operated via an infrared remote, the servo motors drive the legs, solar boom and solar array using a clever pulley system. A simple flower origami solar array is mounted on the PUP, while a more experimental panel that utilizes Miura fold origami is demonstrated separately. This reliable, compact system sits comfortably on the uneven lunar surface, while harnessing the sun to distribute power to other assets.

TEAM MEMBERS

Ryan Christopher Ahearn, *Aerospace Engineering*
Alek Cotnoir, *Aerospace Engineering*
Dara Davoodi, *Aerospace Engineering*
Blake Peter Lobato, *Aerospace Engineering*
Marc Mendez, *Aerospace Engineering*
Kyle Logan Ostendorp, *Aerospace Engineering*
Addison E Plummer, *Aerospace Engineering*
Nicolas Jan Wen Tan, *Aerospace Engineering, Materials Science & Engineering*

COLLEGE MENTOR

Jekan Thangavelauthum

PROJECT ADVISOR

Jekan Thangavelauthum

Interactive Museum Display for Yuma Crossing National Heritage Area

Team 22099

PROJECT GOAL

Provide an educational and interactive system to demonstrate the drastic changes occurring to the Colorado River.

The team designed a special exhibit for the Yuma Crossing National Heritage Area. The interactive topographic display of the lower basin of the Colorado River includes a map with notable landmarks, various facts about the river and audio recordings that can be played.

Visitors can tap a spot on the 32-inch touch screen to display its corresponding information, while LED lights and 3D figures emphasize the specific location on a physical map. The interior of the system includes a Raspberry Pi, wiring and circuitry, and programming to ensure the display runs smoothly.

The new exhibit has drawn more people to the area and spurred an influx of business. By attracting both tourists and Yuma locals, the exhibit is educating broader audiences about the ecosystem of the Colorado River and what needs to be done to preserve it.

TEAM MEMBERS

George A Bueno, *Systems Engineering*
Alexander L Cordero-Torres, *Systems Engineering*
Jose Antonio Espinoza, *Systems Engineering*
Mitzi Hernandez Laveaga, *Engineering Management*
Benny Mariscal, *Systems Engineering*
Erick Raymundo Silva Ballesteros, *Industrial Engineering*

COLLEGE MENTOR

Samuel Peffers

PROJECT ADVISOR

Samuel Peffers

Spent Grain Reuse and Dealcoholizing Process

Team 22100

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

Utilize byproducts from local breweries and distilleries using Oatman Flats' indigenous barley to promote a circular economy, while also designing a solar-assisted beer dealcoholizing process that can be easily implemented in small- to medium-sized Tucson breweries.

Breweries and distilleries produce large quantities of byproduct waste streams, mostly made of spent grain from the mashing process. Typically, these spent grains are donated to a local farmer to serve as feed for livestock. The team repurposed the wasted spent grains into various practical products and composed a life cycle analysis on each product.

Nonalcoholic beer is a product that is not seen at local Tucson breweries. Dealcoholized beer is a valuable product, but the process to produce it is energy-intensive. The team designed a vacuum distillation process to extract the ethanol from beer and lower the alcohol content below 0.5% alchohol by volume, the threshold for nonalcoholic beer. Solar heating was used to improve economics and reduce the environmental impact. The project was simulated on ASPEN software to optimize the process, removing the alcohol efficiently.

TEAM MEMBERS

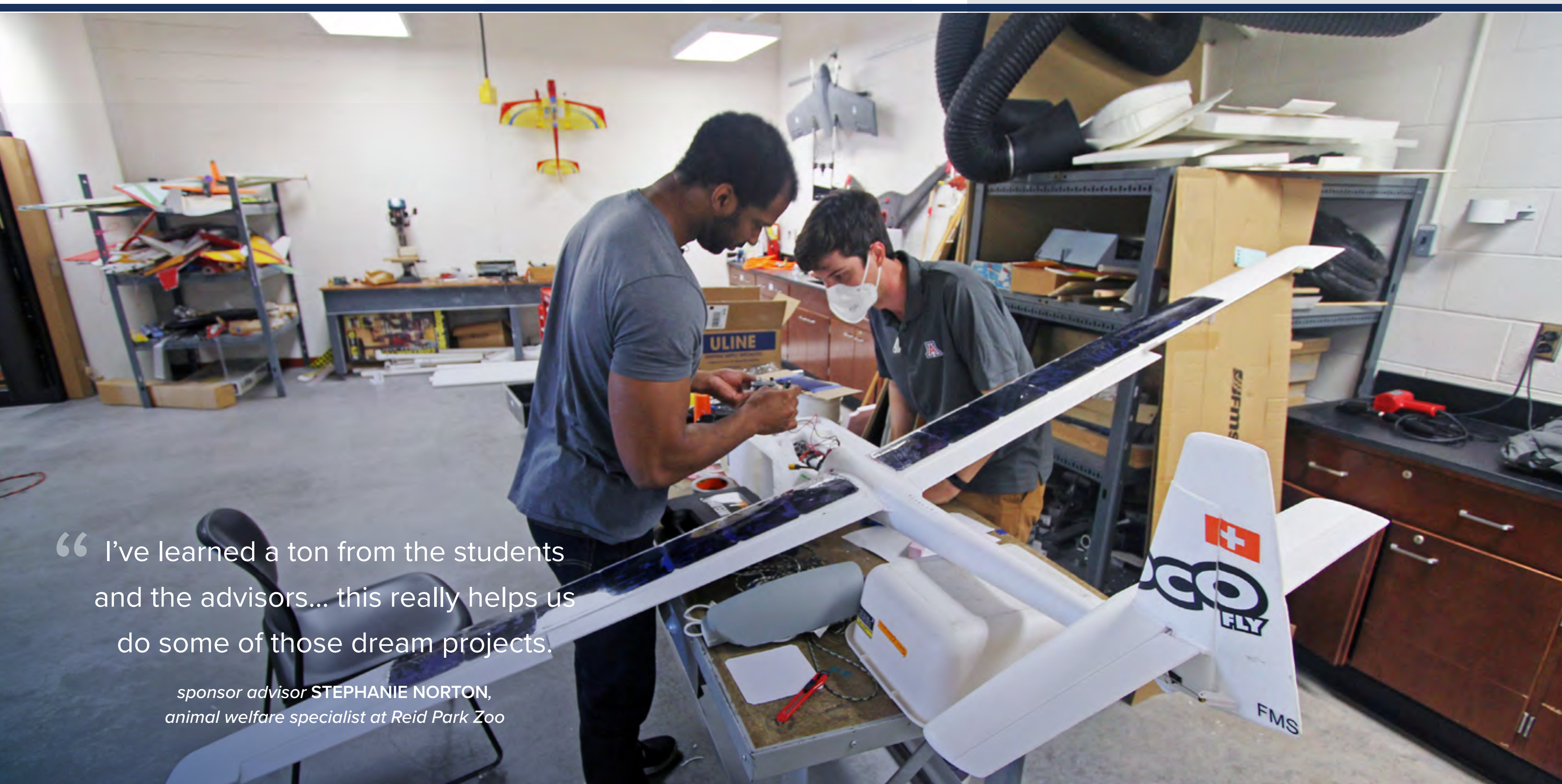
Ian Alexander, *Chemical Engineering*
Sean Alexander, *Chemical Engineering*
Brennan Yoshinobu Breen, *Chemical Engineering*
Marco Jose Garcia, *Chemical Engineering*

COLLEGE MENTOR

Adrianna Brush

PROJECT ADVISOR

Yadi Wang



"I've learned a ton from the students and the advisors... this really helps us do some of those dream projects."

sponsor advisor **STEPHANIE NORTON**, *animal welfare specialist at Reid Park Zoo*

Interdisciplinary Capstone Course and Senior Design Projects
YEAR AT A GLANCE

ENGINEERING DESIGN OPEN HOUSE

SYSTEM REQUIREMENTS
4 weeks

After students are assigned to projects, teams work with their sponsors to generate structured lists of system requirements and metrics for evaluating final designs and prototypes.

SYSTEM REQUIREMENTS MEMO
In this structured document, against which all designs, tests and prototypes are gauged, students define requirements for completed projects in consultation with sponsors.

PRELIMINARY DESIGN
4 weeks

Following approval of the Systems Requirements Memo, teams conduct research and brainstorm to produce preliminary or conceptual designs.

PRELIMINARY DESIGN REVIEW
In this formal review, sponsors and mentors critique conceptual designs – for which sponsor approval is required – challenge assumptions and help teams refine their plans.

DETAILED DESIGN
6 weeks

Based on feedback from sponsors and mentors at the Preliminary Design Review, teams modify their preliminary designs and create detailed manufacturable designs to create prototypes for Craig M. Berge Engineering Design Day.

CRITICAL DESIGN REVIEW
At this milestone, sponsors and mentors ensure their teams are meeting all requirements and have feasible plans to manufacture and test prototypes within budget.

WINTER BREAK

DESIGN CHANGES/ BEGIN BUILD
7 weeks

Following the Critical Design Review and approval of the Critical Design Report, teams begin purchasing parts and manufacturing custom components to produce their prototypes.

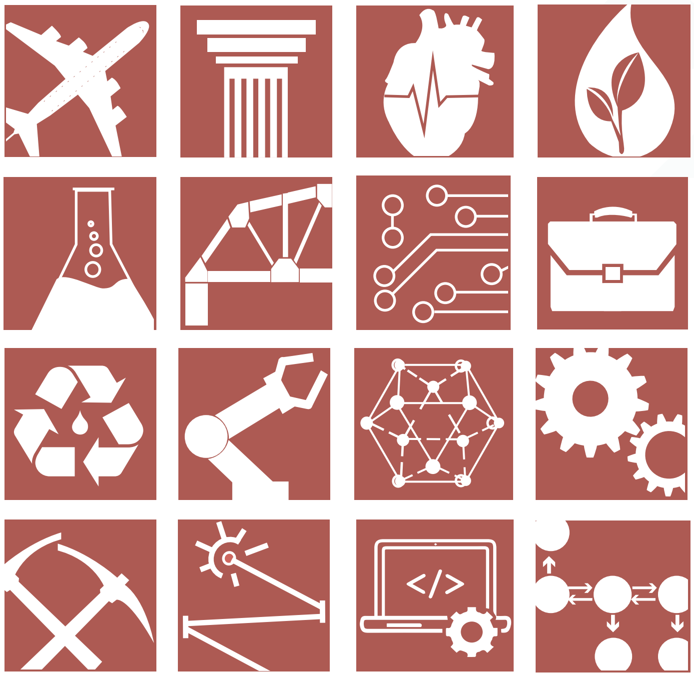
FINAL DESIGN PRESENTATION
In this formal exchange, sponsors and mentors provide project feedback as teams address any last-minute changes.

FINALIZE BUILD/ ACCEPTANCE TESTING
9 weeks

During the last phase of the program, teams collaborate closely with sponsors to assemble and test their prototypes. They also prepare their presentations and demonstrations for Craig M. Berge Design Day.

CRAIG M. BERGE DESIGN DAY

16 ENGINEERING DEGREE PROGRAMS



- AEROSPACE ENGINEERING
- ARCHITECTURAL ENGINEERING
- BIOMEDICAL ENGINEERING
- BIOSYSTEMS ENGINEERING
- CHEMICAL ENGINEERING
- CIVIL ENGINEERING
- ELECTRICAL & COMPUTER ENGINEERING
- ENGINEERING MANAGEMENT
- ENVIRONMENTAL ENGINEERING
- INDUSTRIAL ENGINEERING
- MATERIALS SCIENCE & ENGINEERING
- MECHANICAL ENGINEERING
- MINING ENGINEERING
- OPTICAL SCIENCES & ENGINEERING
- SOFTWARE ENGINEERING
- SYSTEMS ENGINEERING

CRAIG M. BERGE DESIGN DAY

ACKNOWLEDGMENTS

STUDENTS

Capstone projects are the culmination of a year's worth of work. Students have applied knowledge from the breadth of their undergraduate education, exercised out-of-the-box thinking and spent hundreds of hours producing the best solutions for their sponsors. We applaud your dedication and professionalism and congratulate you on your achievements.

MENTORS

Project mentors apply hundreds of years of collective engineering experience to guide students in the completion of their projects. They ensure the implementation of industry standards in the design process. Their expertise in devising solutions to challenging problems adds a critical dimension to students' engineering knowledge. Thank you for your hard work, your commitment to excellence in engineering design and your role in the education of our students.

SPONSORS

Sponsors provide students with real-world questions and allocate funds to the program. They designate technical staff and mentors to steer students through the intricacies and requirements of their projects. Sponsors are a big part of what makes the Engineering Design Program (which encompasses Interdisciplinary Capstone and other capstone courses) what it is today: one of the largest and best-quality programs of its kind in the nation. Thank you immensely for your continued support.

JUDGES

The external judges who participate in Craig M. Berge Design Day supply independent professional assessments of the quality of students' work. They help maintain the accreditation of undergraduate University of Arizona Engineering degree programs by providing insight and suggestions for improving the Engineering Design Program. Thank you for volunteering your time and applying your knowledge to evaluate students' capstone projects.

STAFF

Dedicated professionals in the College of Engineering ensure the program's smooth operation. They spend thousands of hours each year organizing events, communicating with sponsors, operating manufacturing areas, generating marketing materials and news, maintaining budgets and purchasing records, and performing a myriad of other tasks. Thank you all for your invaluable contributions and the excellence you bring to the program.

THANK YOU TO OUR SPONSORS

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Department of Biomedical Engineering
Department of Biosystems Engineering
Department of Chemical & Environmental Engineering
Department of Electrical & Computer Engineering
Department of Mining & Geological Engineering
Department of Systems & Industrial Engineering
Lunar and Planetary Laboratory

THANK YOU, MENTORS & STAFF

MENTORS

Mark Brazier
Adrianna Brush
Salvatore Caccavale
Pat Caldwell
Elmer Grubbs
Heather Hilzendeger
Justin Hyatt
Steve Larimore
Huy Le
Doug May
Don McDonald
Bob Messenger
Mike Nofziger
Gregory Ogden
Kimberly Ogden
Sharon ONeal
Samuel Peffers
Brad Ross
Sergey Shkarayev
Jekan Thangavelauthum
Scott Wright

STAFF

Larry Head – *Craig M. Berge Engineering Design Program Director*
Debbie Claggett – *Engineering Design Capstone Coordinator*
Cecilia Lopez - *Business Manager*
Ismael Hernandez – *Purchasing Office*
Logan Deane – *Purchasing Office*

THE UNIVERSITY OF ARIZONA
COLLEGE OF ENGINEERING
Craig M. Berge
Engineering
Design Program

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From startups to Fortune 500 companies, a varied group of sponsors benefits from this outstanding interdisciplinary academic program each year.

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- Explore new technologies
- Move products to market
- Support engineering education
- Boost company profile on campus

TRANSFERRING SKILLS TO THE WORKFORCE

Teams of four to six seniors, mentored by industry liaisons and University of Arizona Engineering faculty, spend an entire academic year taking your design projects – many of which become patented technologies and commercial projects – from start to finish.

View the **2022 Engineering Design Day** and **project presentations** at **b.link/DesignDay2022**.

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