



**Daniel Felix Ritchie School  
of Engineering & Computer Science**  
UNIVERSITY OF DENVER

# *Ritchie School Senior Design Showcase*

**Friday, May 19, 2023**

**Daniel Felix Ritchie School of Engineering and Computer Science**

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*Driving Ethical Innovation*

# DRIVING ETHICAL INNOVATION

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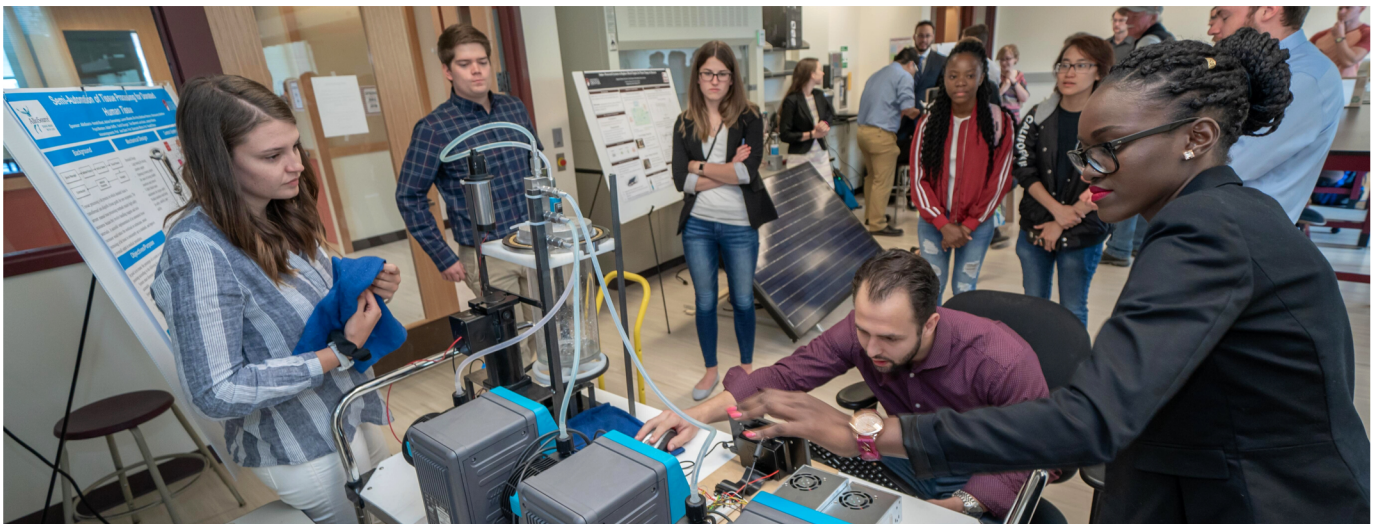


# SENIOR DESIGN

## *Interdisciplinary Teams + Industry Projects = A Powerful Senior Capstone Experience*

The Senior Design Project provides undergraduate students with an integrated, mentored, requirements-based design project, giving students the opportunity to serve on self-directed teams. Each project team will conceive, design, prototype, verify and validate a system to solve a specific customer problem. Through teamwork, critical thinking and thorough systems engineering procedures, senior design projects allow students to apply the fundamentals learned in their first three years in a research and development project.

Senior Design is a year-long course required for all engineering seniors to graduate. Each team of 4-5 seniors is mentored by both the Engineering faculty and their project sponsor. Sponsors gain the first-hand experience of working with potential future employees to see their project to fruition. Our seniors hone their collaborative team skills while fulfilling their commitment of creating real-life deliverables for their sponsors.



# SCHEDULE

## Senior Design Pitches and Q+A

10:00 a.m. - 11:00 a.m. >>> *ENGINEERING & COMPUTER SCIENCE BUILDING 510*

## Senior Design Demonstrations

11:00 a.m. - 12:30 p.m. >>> *ENGINEERING & COMPUTER SCIENCE BUILDING 510*

## Senior Design Presenters Pizza Lunch

12:30 p.m. - 1:45 p.m. >>> *ENGINEERING & COMPUTER SCIENCE BUILDING 143*

## Industry Advisors and Senior Design Sponsors' Lunch

12:30 p.m. - 1:45 p.m. >>> *ENGINEERING & COMPUTER SCIENCE BUILDING 510*

## Industry Advisory Board & Industry Advisory Council Meetings

2:00 p.m. - 3:30 p.m. >>> *INDUSTRY ADVISORY COUNCIL, ECS 357*  
*INDUSTRY ADVISORY BOARD - MME, ECS 400*  
*INDUSTRY ADVISORY BOARD - ECE, ECS 401*



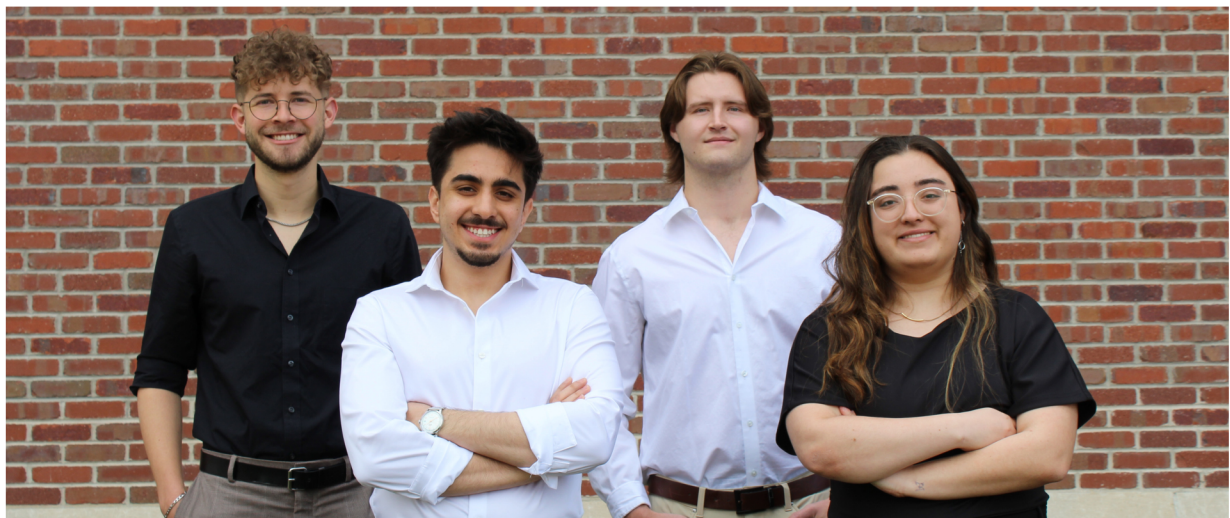
# Accessible Algebra

*Sponsor: Blind Institute of Technology*



The Blind Institute of Technology (BIT) is a non-profit organization aimed at advancing professional opportunities for Blind/Visually Impaired people. The goal of BIT is to equip blind/visually impaired people with the toolset needed to succeed in the corporate world. Many blind/visually impaired students start falling behind in mathematics around the 7th and 8th grades because math concepts like algebra and geometry are taught using visual methods, such as whiteboard drawings and pen-and-paper exercises. Typically, students must seek out specialized instructors outside the classroom in order to progress in the subject. The goal of this project was to create a device that can translate visual concepts of algebra into multiple sensory channels that can benefit the blind/visually impaired community.

The resulting design is a tactile math display with a companion IOS application that aims to make mathematical problem-solving more approachable and accessible for blind/visually impaired students. The tactile display uses an array of raised, mathematical operators, numbers, and letters. The tactile display maneuvers the characters to display a variety of equations and operations that can be felt by the blind/visually impaired student. A companion application is wirelessly connected to the display system, which allows teachers and students to send equations to the tactile device for display. Moreover, using the accessibility setting provided with iPhones, students will be able to receive auditory feedback on all the equations that they are dealing with, providing a multi-sensory mathematical experience. We intend for this system to increase professional and educational opportunities for the blind/visually impaired. The devices should allow blind/visually impaired students to more effectively integrate into higher levels of education.



Team Members (left to right): Ian Mattox, Ameen AlShaiBani (Team Captain), Thorin Stormo, Andrea Francis

# In-Lab Alpine Simulator



## Sponsor: BOA Technology

BOA is a global company dedicated to improving athletic performance. They specialize in high performance fitment systems for snowsports, running/training shoes, cycling, golf and many more outdoor industries. They are best known for their 'Fit System', which consists of 3 main elements - the dial, laces and guides - that when implemented correctly, enhances the fit, performance, and comfortability to the individual wearing it.

BOA's origin, and one of their largest focuses as a company, is in the snowboard boot fitment systems. In addition, they have recently gotten into the ski boot business. Studying the biomechanical impact of fit in winter snow-sports comes with unique challenges. Being based in Denver, it is very time consuming and requires a lot of coordination to get products, testing equipment, and athletes to the mountains. In addition, weather conditions and season do not permit for products to be tested year round. To combat these challenges, the design team was tasked with building an In-Lab Alpine Simulator that, when used in combination with insole pressure mapping tools, gives BOA researchers the opportunity to study the biomechanical impact of fit in snow-sports in their Performance Fit Lab year round.

The alpine simulator is a two year project. In the first year, the previous design team created the base design model using the stipulations given by BOA Technology. In order to incorporate everything that BOA would need and want, the following requirements were established: the system must be incorporated into the pre-existing Fit Lab, height and angle adjustments, mobility and storage, surface must mimic frictional characteristics of snow, rider access to the top of the snow and staging area for donning equipment, and safety features to ensure rider safety at all times. Considering these requirements, the system favors width over length, a substructure composed of steel members able to support dynamic loads, a revolving carpet ranging from 0-12.5 mph, an angle adjustment system that allows the angles between 9.5-17.5 degrees, and the budget costing less than \$25,000, a cheaper alternative than ski treadmills on the market.

For the second year, our team took over beginning in the Fall quarter of 2022, with the goal of optimizing and completing the groundwork laid by the first year's design team. The deck was redesigned in order to increase stiffness, and the beams holding the deck were lowered to be tangent to the roller. In addition, the screw-jacks were moved under the load points, and the I-beam was extended to accommodate the buffer zone. Once the necessary retrofits had been made, the team assembled the system using a test carpet to verify that the system's dynamics were functional. The system was then moved to the BOA fit lab and assembled with the final belt, anchoring the system to the concrete floor and gluing the snow material to the belt.

The system designed over the two years will allow for BOA to easily test their snowsport products year-round. In addition, with testing taking place in the lab, it will be significantly easier to utilize testing equipment such as camera motion capture system, force plates, and insole pressure mapping tools. The total cost of the design came to less than half the cost of similar ski simulators that can be purchased, making it more feasible to implement a similar system for demoing equipment at ski/board shops or for recreation use.



Team Members (left to right): Darius Soo Hoo, Rick McIntyre, Peyton Weeter, Nate Sullivan, Tom Mullin, Kyle Bucholtz

# Adapted Guitar Chord Mechanism



NEUROREHABILITATION  
& RESEARCH HOSPITAL

## *Sponsor: Craig Hospital*

Craig Hospital is a world-renowned rehabilitation hospital that exclusively specializes in neurorehabilitation and research for individuals with spinal cord injury and brain injury. One of the ways Craig Hospital addresses spinal rehabilitation is through music therapy. Their neurologic music therapy program aims to provide live-music experiences which facilitates the recovery of nonmusical functions. Musical aspects such as rhythm, melody, and volume have been proven to be processed by the brain in the same areas that are fundamental for motor planning and coordination. Through experience Craig Hospital has shown music therapy is a strong tool in restoring motor function and communication skills. To further develop its music therapy program Craig Hospital has asked this team to develop a device that would allow their patients to play the guitar.

The mission of this senior design team was to design and fabricate a mechanical device that translates gross motor function into chord depression in the form of six different chords. The resulting design is broken down into four subsystems, a user interface, multiplexer, chord depression subsystem, and attachment mechanism. The user interface was designed for spinal injury patients with limited motor function, selecting their desired chord through a vertical lever interface. The multiplexer takes the user input force and separates it into the necessary fret locations that must be depressed for each chord. The chord depression subsystem utilizes 13 rotating cams which are activated through the multiplexer to produce fast and reliable fret engagement. Additionally, this subsystem includes spring loaded reset rods, automatically returning the cams to a neutral position after user release. These subsystems are housed and secured to the guitar by the attachment mechanism. The resulting final design allows rehabilitation patients to seamlessly transition between the provided six chords while using our slick and robust device.

The goal of this device is to enable spinal cord patients to be able to play the guitar within Craig Hospital's music therapy department. Designed to remove the physical aspect of guitar playing, our team has produced a device that functions with the weight of the patient's arm, and minimal rotation of the shoulder. This results in patients experiencing motor loss correlated to C4-C8 spinal nerve injuries, regaining the ability to play the guitar. Our device provides an emotional outlet that has been previously unavailable for patients at Craig Hospital and beyond.



Team Members (left to right): Patrick Miller, Garth Staniar, William McCreedy

# Drone Sensor Package for Remote Medical Triage



## *Sponsor: DeNOVO Solutions*

DeNOVO Solutions is a Minority/Service-Disabled Veteran Owned Small Business, which delivers agile engineering solutions and intelligence analysis to support a broad variety of customers. DeNOVO Solutions creates strategic and tactical relationships to significantly improve the value and capabilities in the Defense of our Nation and its Allies, delivering trusted professional and engineering services, specializing in software development and integrations of highly critical systems.

DU engineering team has partnered with DeNOVO to develop a health sensor package for drones that can measure vital signs and provide critical information to rescue teams before they even arrive on the scene. By arriving ahead of rescuers, the drone equipped with the health sensor package can locate victims, measure vitals, and guide them through basic self-first aid, all while the rescue team is en route.

The health rescue package collects information from the victim which can be delivered to a medical unit or rescue team through its subsystems that include a camera for imaging, sensor packages, transmission system, mechanical device for lowering, and communication component. The design allows for the ability to be wired and used on multiple types of drones through a universal mounting plate. The transmission and communication components facilitate communication in the event the victim can administer self-care, providing first aid support and instructions to the victim guided through a remote operator.

By providing critical information to rescue teams, our technology has the potential to save lives and make emergency response times faster and more efficient than ever before. The prototype is meant to scan and detect the victim of an accident or natural disaster to allow for medical support or rescue teams to triage the care for victims and come better prepared with information to allow them to quickly address the situation while arriving at the scene. All this while being supported by remote capabilities where others can contribute to diagnosis, urgency and care needed to address different scenarios.



Team Members (left to right, top to bottom row): Jack Harwood, Adam Hangland, Jack Thompson, Diego Daza-Diaz, Cyrus Jumalon



# Non-Electric Negative Pressure Wound Therapy (NPWT) Device for Low Resource Contexts



## *Sponsor: Design Outreach*

Design Outreach (DO) is a non-profit organization dedicated to creating solutions for lasting change. They focus their work on marginalized communities in Africa, Haiti, and Central America. There are many communities in these countries who live in challenging environments that are drastically different from the environment in countries like the United States. One challenge DO is addressing is the lack of appropriate medical resources. Many medical centers in countries like Malawi are often short staffed with varying medical experience levels, and unreliable electricity. The climate consists of elevated temperatures, fluctuating humidity, and dust that often damages electrical components. For this reason, most of the equipment that is donated to these countries is often useless and thrown away in growing landfills.

To combat this problem, DO has instructed this team to create a medical device that can survive these conditions. The medical device chosen for this project is a Negative Pressure Wound Therapy Device (NPWT) --also known as a vacuum-assisted closure device. The device is made to draw exudate and air from a wound site so that it can heal fast and efficiently. Considering the financial constraints of these countries, the team chose components that were long-lasting and low-cost. Furthermore, to meet FDA regulations, the device must draw a maximum of 125 mmHg of negative pressure at the wound site, and every component must be sterilized using a sterilization solution or an autoclave.

The designs of the NPWT device created by the team centered around three concepts. First, the device must be robust enough to withstand the environment of the countries the device is being used in. Second, the user interface must be easy to understand so that anyone can use the device regardless of their medical training. Finally, the device must be completely non-electric, therefore, only use a mechanical energy source.

The final design of the vacuum assisted closure device utilized the following components: mechanical energy source, peristaltic pump, exudate container, pressure regulator, and surgical tubing which can be attached to a wound dressing. The mechanical energy source uses a rack and pinion gear to turn gravitational potential energy into rotational motion. A damping piston is used to control the duration of the energy source and modular weights are used to control the torque output. The pressure regulator ensures that the wound vac can be easily set to 125 mmHg. This component is connected to a peristaltic pump that uses a rotational torque to draw fluid through the surgical tubing. Any exudate drawn from the wound site is dumped into an exudate container that will be cleaned and emptied regularly.



Team Members (left to right): Lucas Rininger, Rory Taylor, Shweta Raje, Axel Garfio, Gabriel Davis

# Game Changin' Controllers



*Sponsor: ICEBOX*

ICEBOX designs and builds competitive game controllers that offer a reliable and long-lasting gaming experience featuring improved response time and ergonomics. Making an ICEBOX controller was previously a timely process, and this project aims to create a rendition of their controller that can be rapidly manufactured at a medium scale. The system includes the case, connector cable, PCB, and software.

The case has been redesigned so that it may be 3D printed or injection molded while maintaining an acrylic top sheet. In doing so, the PCB had to be changed to account for the new design and new features. Finally, the existing code must be adapted to work properly with the improved PCB design and our button matrix design should aid in improving the response time. The components have been designed for manufacturing while keeping style, reliability, and ease of use in mind.



Team Members (left to right): Diego Esparza, Jimmy McGlynn, Ryan Farrell, Jimmy McGlynn

# Augmenting the Human Workforce with ATOM, an Autonomous Material Delivery System

*Sponsor: Lockheed Martin*

**INTRODUCTION:** Current methods for delivering payloads across Lockheed Martin campuses involve employees loading and driving large gasoline trucks and vans. This approach results in the release of air pollutants and disruption to personnel workflow; thus, alternative methods for material delivery are being explored. Lockheed Martin tasked a team of student engineers at the University of Denver to design a robotic delivery system that can move a payload weighing no more than 40 lbs. and no larger than 2 ft. x 2 ft. x 2 ft. between two locations safely, reliably, and without human intervention.

**METHODS:** Project commencement involved interviewing the sponsor to understand customer requirements and constraints that would influence the system's form and functionality. Weekly forums and progress reports were established with the project sponsor to address technical questions. Using data gathered through student-sponsor meetings, the team developed a minimum viable product (MVP) document that outlined the robot's features to be demonstrated by the project's end. Essential MVP goals include:

- Open and modular software architecture
- Autonomous and user-guided navigation
- Detection and avoidance of obstacles
- Powering down motor-driven wheels upon activating a software or physical kill switch

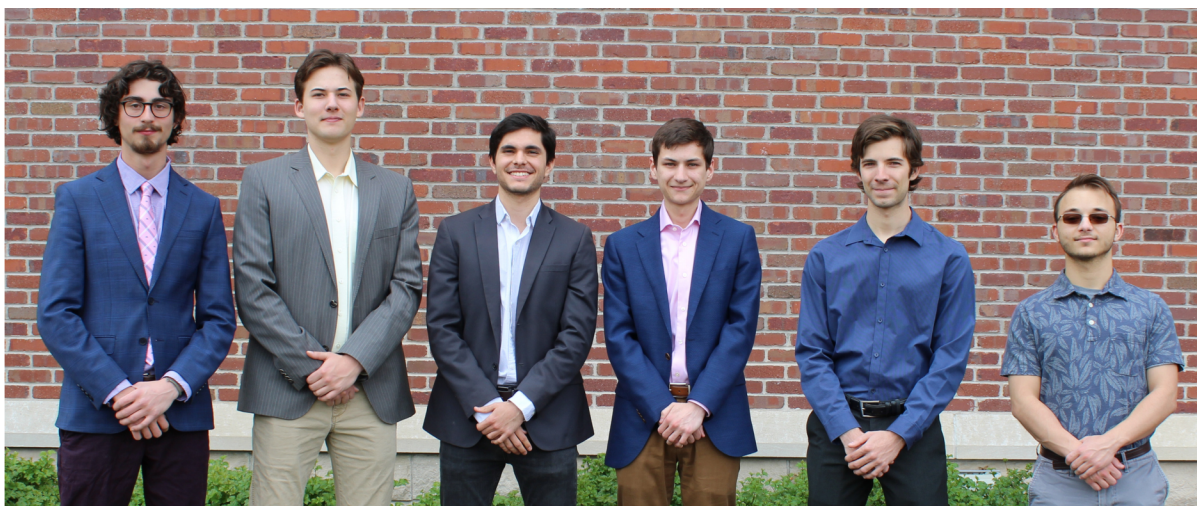
The MVP narrowed the types of electronics that could be installed into the system and aided the design of mechanical components and software development. Upon defining the robot's functionalities, responsibilities were divided amongst the team's members:

- Two engineers focused on the design and fabrication of mechanical structures
- Three engineers coded and trained object detection and recognition algorithms
- One engineer designed path-planning algorithms

Integrating hardware, electronic, and software modules into the system will follow the manufacturing and verification of physical components and computer programs. The project's conclusion will involve validating the completed robot on the University of Denver campus and the Lockheed Martin Highlands Ranch campus, during which obstacle courses simulating the robot's working environment shall be established.

**SIGNIFICANCE:** The project's objective was to develop the framework of an autonomous material delivery system that reduces the time Lockheed Martin personnel devote to the delivery of payloads while maintaining a cleaner environment. The system designed for the 2022-2023 Senior Design project allows Lockheed Martin to expand upon the device to continue improving workflow efficiency while supporting the company's "Go-Green" initiative.

**ACKNOWLEDGEMENTS:** The University of Denver student team would like to thank Lockheed Martin and the University of Denver engineering faculty for their support throughout the project.



Team Members (left to right): Xavier Zuvekas, Benjamin Schwartz, Federico De Zabala, Carter Sorensen (Team Captain), Kolton Lee, Brooks Carrico

# ACKNOWLEDGEMENTS

Thank you to all Senior Design Project sponsors, industry advisory members, faculty, staff, and students involved in our Ritchie School Senior Design Showcase. Thank you to our Senior Design course instructors, Dr. Daniel Auger, Dr. Rachel Horenstein, and Dr. Irvin Jones.

Thank you, friends, family, and support systems who contributed to the success of our students who are showcasing multiple years of hard work and dedication to their studies.



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