Division of Engineering Science
UNIVERSITY OF TORONTO

Engineering Design Portfolio

Allan Zhou

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Who am I?

I am Allan Zhou, an Engineering Science student (Class of 2027 & PEY) at the University of Toronto. I am pursuing the Electrical and Computer Engineering specialization.

Understanding Myself

Leader

I possess critical skills in **presentation** and **initiative**.

Innovator

My engineering experiences have shaped my **problem-solving** and **creativity**.

Teammate

I effectively **communicate** and **collaborate** with others.

Learner

I deploy a **growth mindset** for **lifelong learning**.

The Appearance of My Design Portfolio

My Design Portfolio is organized into a series of **poster presentations**. As a **leader** and **student engineer**, presenting is how I **effectively express my work** to people of various backgrounds.

My growth as a presenter has been accelerated by my 2023-2024 positions:
- **Driverless Firmware Lead** | University of Toronto's Formula Racing
- **Mentor** | Bloor Collegiate Institute's FIRST (For Inspiration and Recognition of Science and Technology) Robotics Competition Team
- **Software Engineer** | LifeTein

Poster presentations best represent my beliefs on engineering design: fulfilling an objective (communicating my engineering projects) while being attractive to those interacting with them.

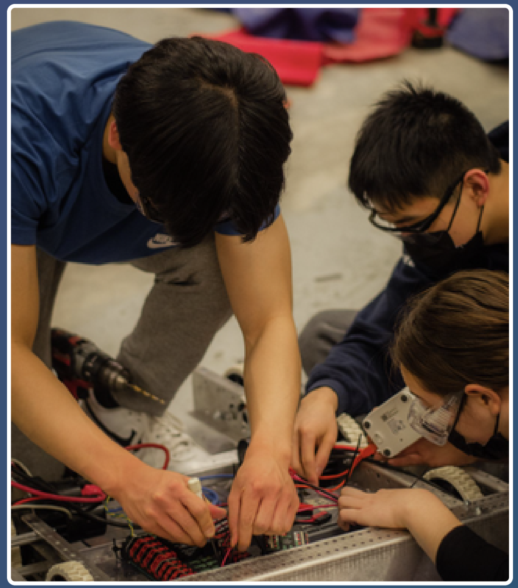
My Practice of Engineering Design

My Beliefs

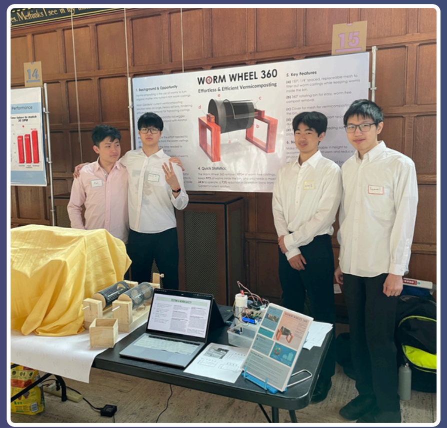
Engineering Design is the ***balanced*** process of creating solutions to achieve critical stakeholder objectives while being attractive to those interacting with the products.

I engage in engineering design to...

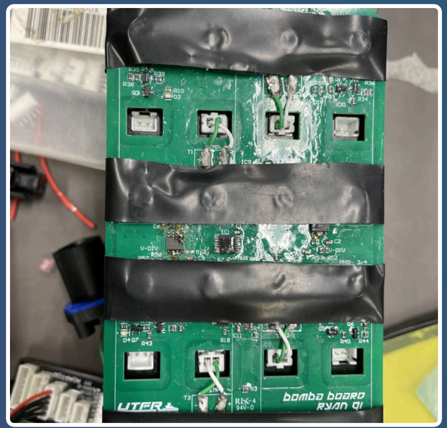
- Pursue projects with **real-world impact**
- Improve the **life quality** of **stakeholders** with my technical passions
- Continue growing as an **engineer** and **person**



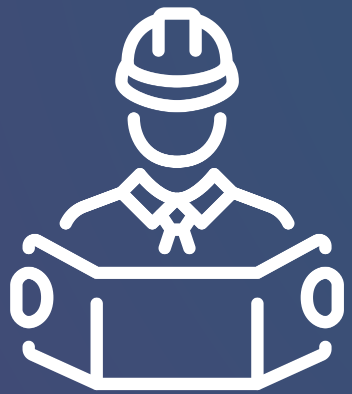
My Values



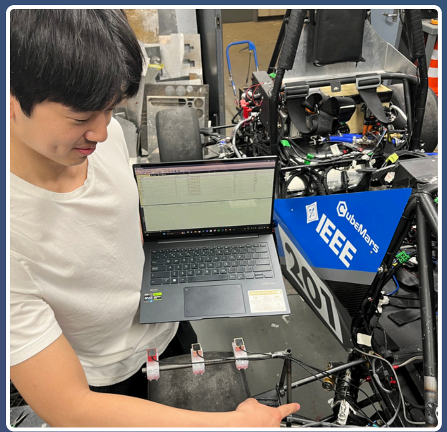
Collaboration



Learning



Leadership



Innovation

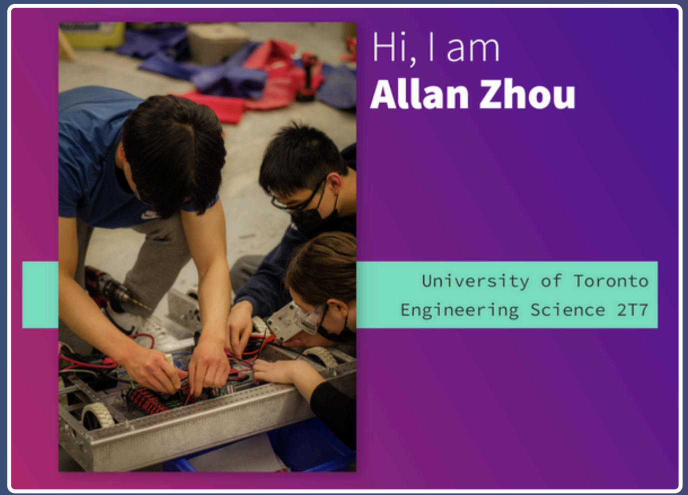
My Perception

- As a leader who values strong communication, **more outspoken stakeholders** often have greater influence on my decisions
- I approach problems by emphasizing **logical and technical** solutions
- I believe inevitable failures must be learned from to **avoid similar future mistakes**

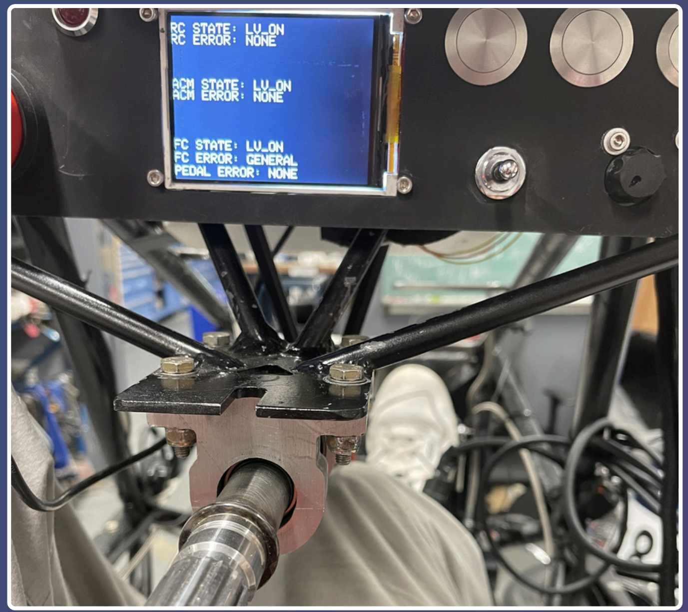
Presenting at Praxis II Showcase.

My Skills

- Software Engineering
  - Front End Development (CSS, HTML, JavaScript)
  - Data Science (Python)
  - Version Control (Git, GitHub)
- Electrical Engineering
  - Printed Circuit Board Design (Altium 365)
  - Harnessing, Crimping, Soldering
  - Electronics Firmware (C++, PlatformIO)
  - Communication Protocols (CAN, I2C, SPI)
- Leadership
  - Effective communication and organizational skills in managing large teams
  - Logistical and business experience on engineering projects



My custom personal website, allanlzee.github.io/allan.zhou/.



Testing out the acceleration pedal of the 2024 electric vehicle designed and built by University of Toronto Formula Racing.

Linear Actuator Control Module

Custom printed circuit board (PCB) for controlling linear actuators on Engineering Design Lab's amphibious vehicle for the Canadian Armed Forces.

ENGINEERING DESIGN LAB

1. Overview

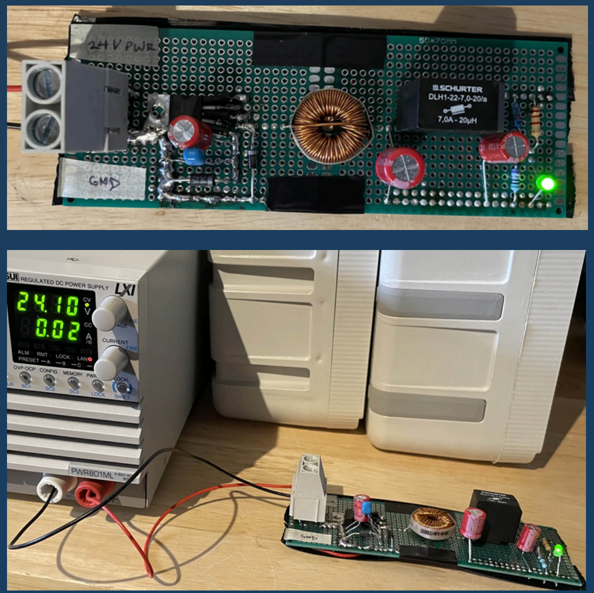
Key Requirements:

1. Power regulation for linear actuators and PCB hardware.
2. High performance motor control at high current draw using Pulse Width Modulation (PWM).
3. Microcontroller operation to read quadrature encoders, control motors, and communicate with other boards over CAN and I2C.

2. Featured Circuits

1. Synchronous Adjustable DC/DC (Buck) Converter (with LC filter, electrolytic decoupling capacitors for ripple management, ceramic capacitors for thermal stability)
2. Low Dropout Regulators (with decoupling capacitors)
3. CAN Communication (common mode choke filtering, transceiver, bus capacitors)
4. STM32 Control (using external crystals, power decoupling capacitors, ST Link programmers)
5. Full Bridge Bootstrap Circuits (with external field-effect transistors, bootstrap capacitors)
6. Safety Fuses, TVS Diodes, Flyback Diodes

3. Circuit Prototyping and Validation



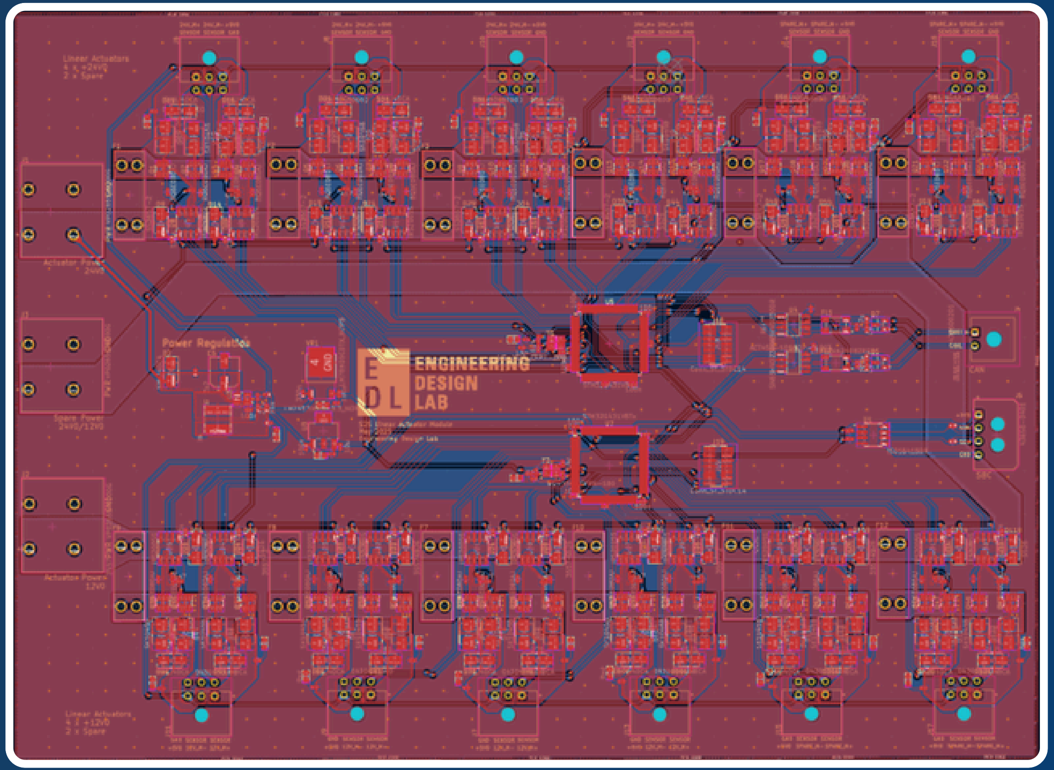
Testing and validating synchronous buck converter and LC filters.

Validating bootstrap full bridge response to PWM inputs at various duty cycles.

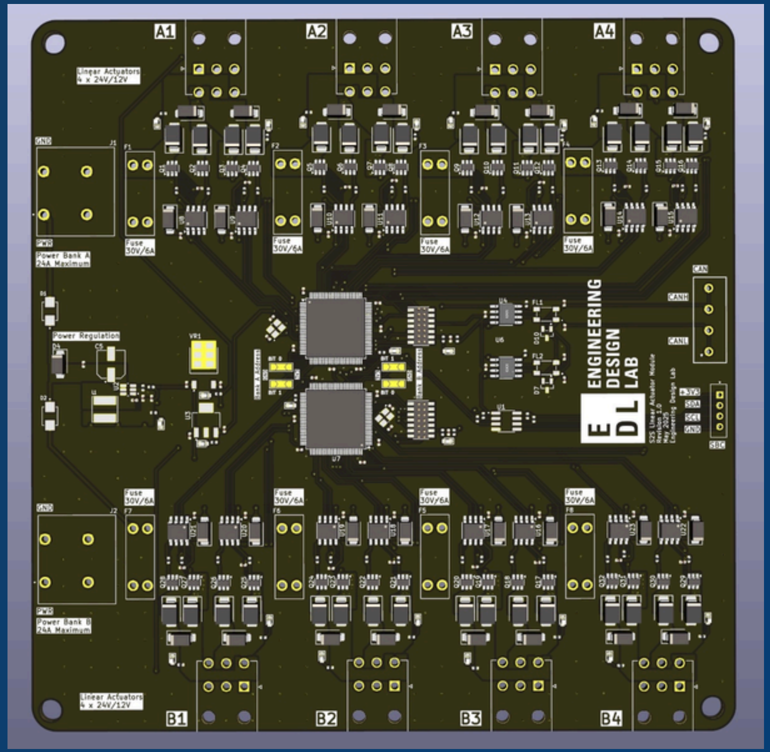
Fixes:

1. Extra decoupling capacitors on full bridge ICs to suppress transients on power supply.
2. Increase in bootstrap capacitance to avoid premature discharging.

4. Circuit Design and Layout



Layout for Linear Actuator Module (V1) adhering to best practices for electromagnetic interference in KiCad.



3D view of the Linear Actuator Module (V2) in KiCad.

High Voltage Box Board

Custom printed circuit board (PCB) for controlling high voltage vehicle systems for the University of Toronto's Formula SAE Electric Vehicle.

University of Toronto Formula Racing

1. Overview

Key Requirements:

1. Galvanically isolated power regulation between low voltage (LV) and high voltage (HV) systems.
2. HV system active indicators and measurement points to determine vehicle safety.
3. Discharge of powertrain energy upon shutdown.

2. Objectives for High Voltage Box Board

Regulation Compliant

New designs for HV power electronics must follow additional safety and performance regulations.

Durability

Every component must be designed to withstand extensive high voltage vehicle operations.

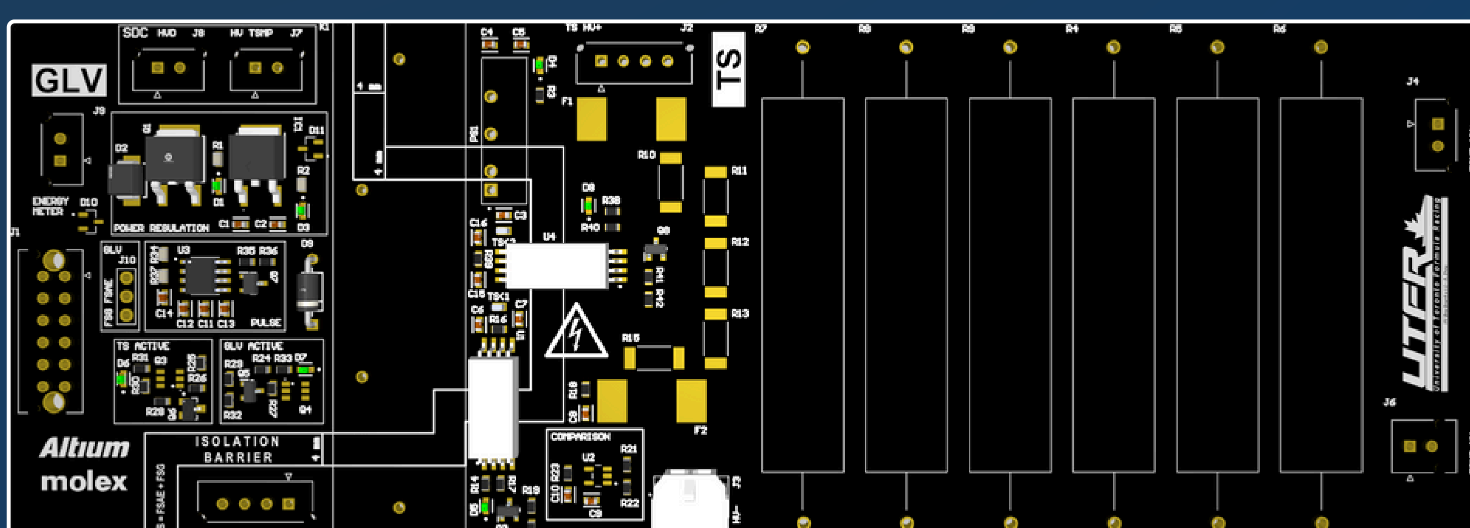
Accuracy

Electronics must be able to control vehicle systems to produce accurate signal measurements.

3. Design, Build, Validate

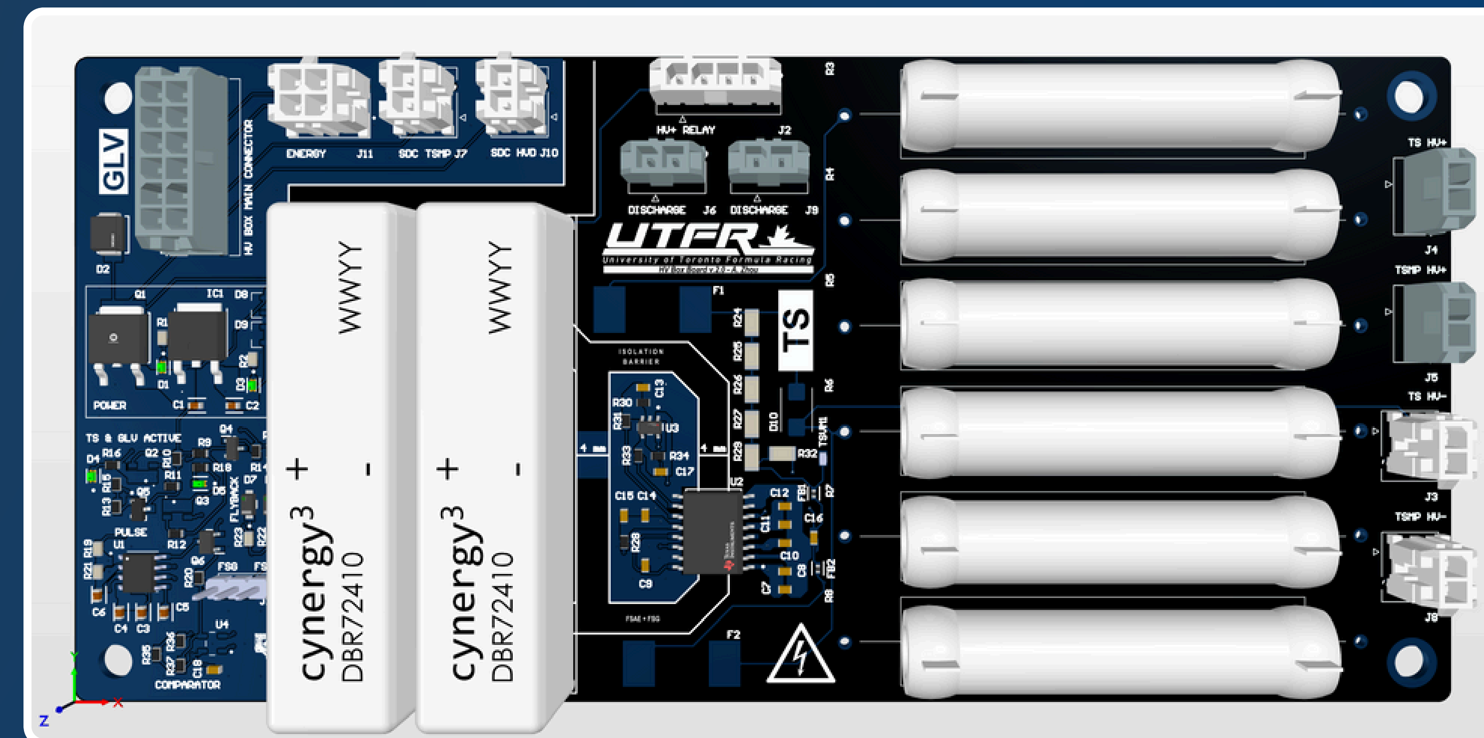
Critical circuits designed and undergoing testing:

- Isolated op-amp for galvanically isolated power regulation.
- Optocouplers driven by semiconductors (MOSFETS) for isolated signal transfer.
- Signal comparators and low power timers for driving active lights.
- Reverse polarity protection and linear dropout regulators for LV power.
- Discharge circuitry for safe vehicle shutdown within timing regulations.

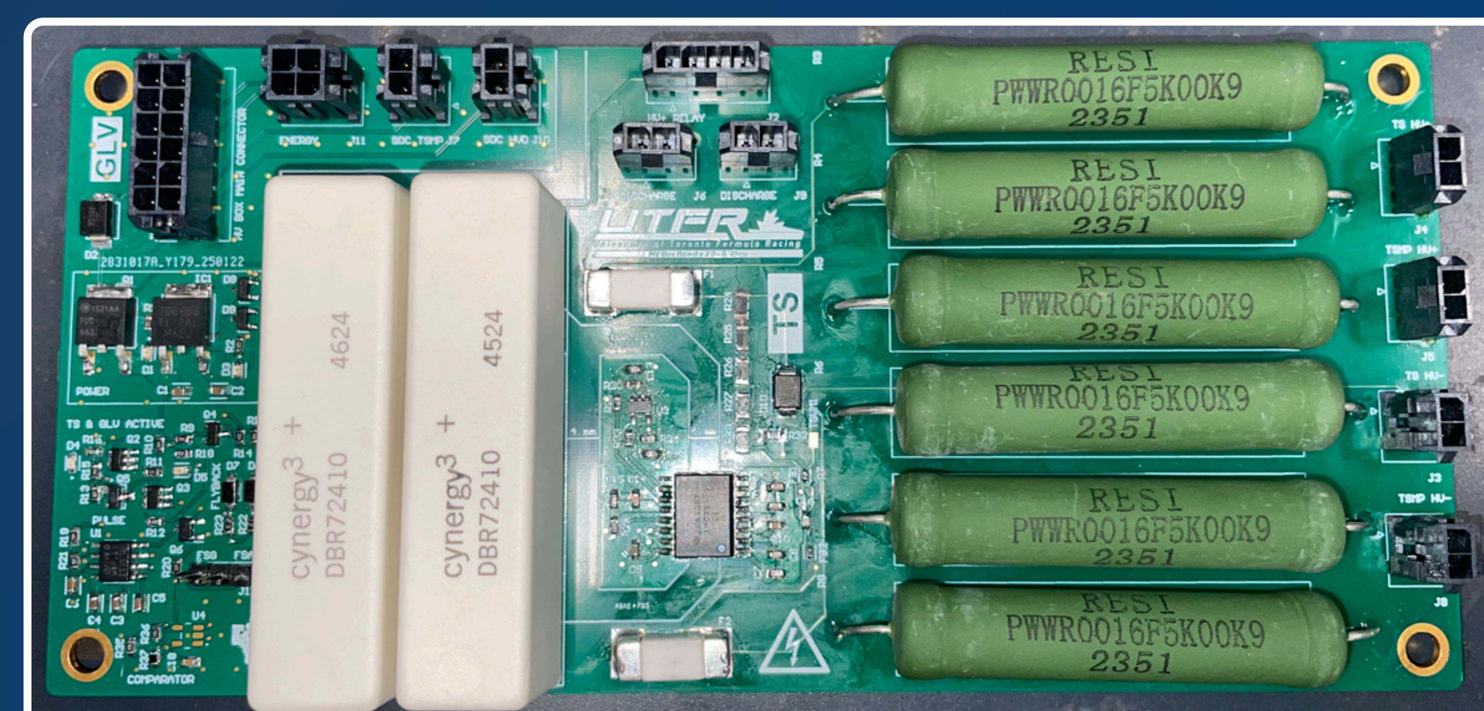


Preliminary layout designed using Altium for the High Voltage Box Board.

4. Final Revision



CAD Model of the High Voltage Box Board (Solidworks).



Fully soldered and tested High Voltage Box Board. Implemented onto Toronto's 2025 Formula Electric Vehicle.

Wildfire Robot

Prototype all-terrain six wheel drive robot with rotatable arms and mulchers for maintaining firebreaks in Western Canada.

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1. Overview

Key Requirements:

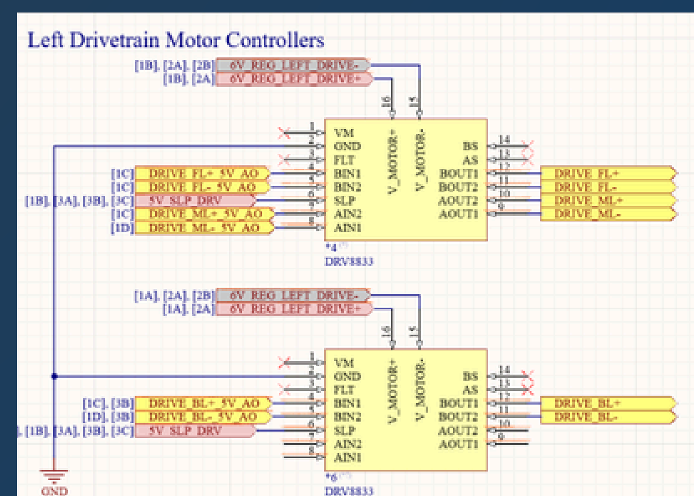
1. All-terrain navigation under various environmental conditions over long durations.
2. System reliability in remote-controlled operations through wireless communication.
3. Effective debris breakdown and removal to manage flammable debris.

2. Design

Mechanical Design

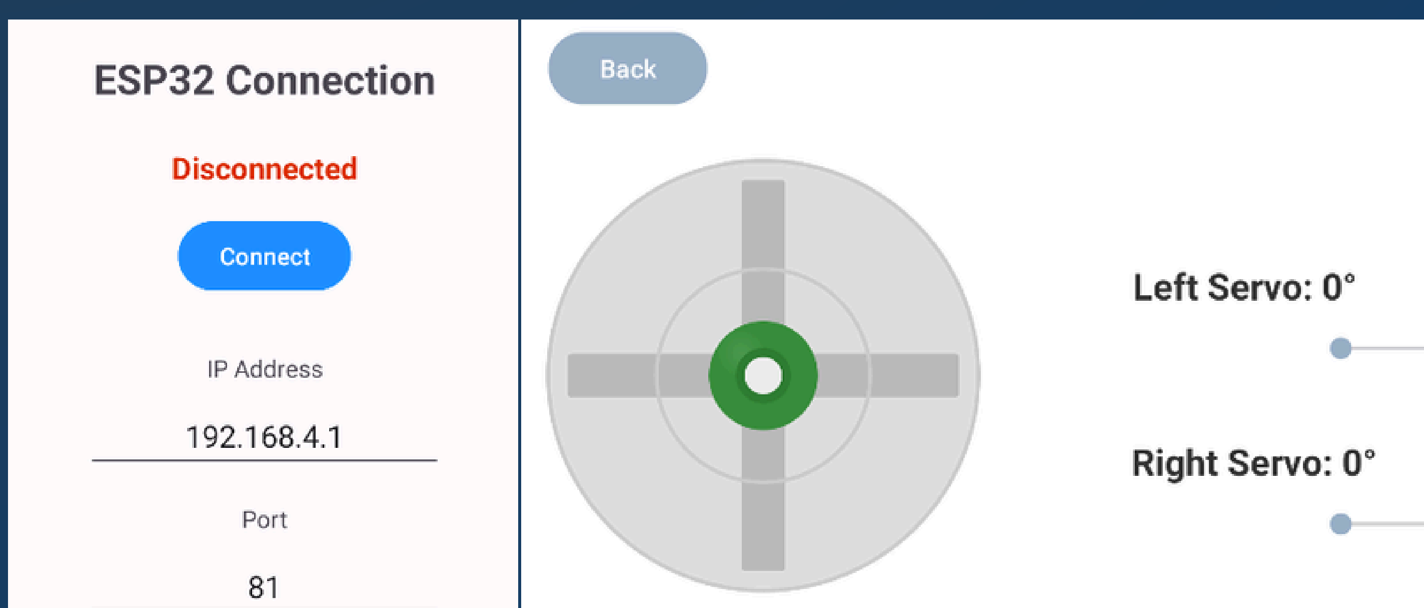
Solidworks assembly of the chassis, drivetrain, and powertrain mechanical components.

Electrical Schematics



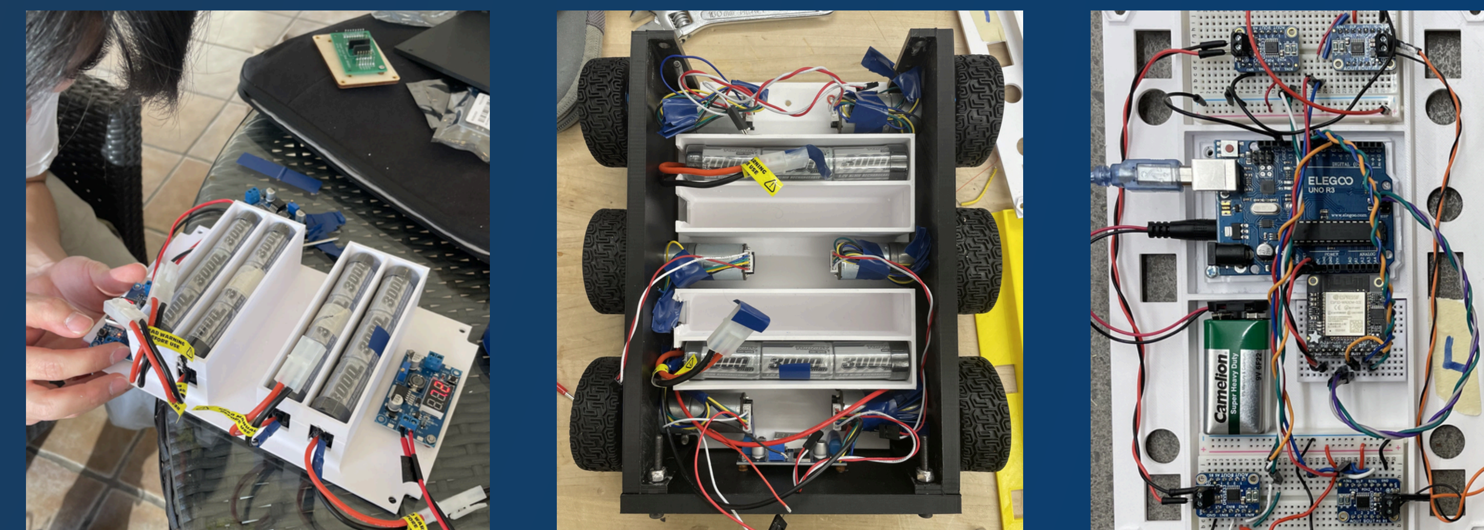
Full bridge circuit design for high performance motor control using Altium.

Firmware and Software Control



User interface of the Android Studio app controlling the robot over WiFi using an ESP32 Airlift communicating over SPI with an Arduino microcontroller.

3. Integration and Testing



Integrating power conversion architecture (batteries and buck converters), drivetrain motors and encoders, and full bridge motor actuation and WiFi operation circuitry for the six wheel robot.

Testing power draw and actuation of individual motors, various control algorithms to optimize navigation in outdoor environments, and arm actuation and mulcher rotation to manage flammable debris.

4. Results and Improvements for Full Scale Design

1. Successful navigation using lowered center wheel drivetrain at 88% power efficiency for sustainable motor actuation over long distances. Larger wheels, suspension, and increased cell capacity would aid with difficult obstacles and longer endurance.
2. Opportunity for improvement with wireless operation by improving SPI communication and power management with the ESP32 Airlift Module.
3. More testing of debris management system to test mechanical durability and reliability in environments more similar to forests prone to wildfires.

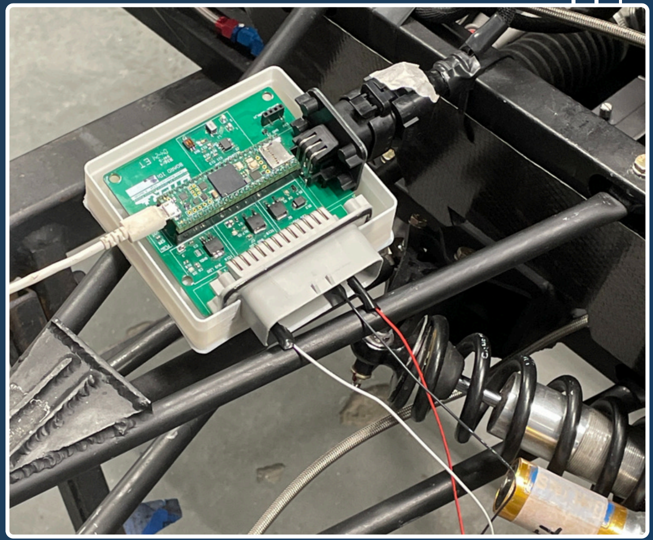
Corner Modules for Vehicle Data Acquisition

Custom printed circuit boards for providing critical vehicle data on tire health, braking, shock absorption, and electric motor behaviour through Controller Area Network (CAN) communication.

1. What are corner modules?

Corner modules (designed by Samar Qureshi, ECE 2T6) are compact circuit boards connected to vehicle sensors through intricate wiring to retrieve feedback data when driving. Racing data collected by corner modules is **critical for improving vehicle design**, particularly for tire management, brake effectiveness, reducing any abrupt force exerted on the driver, and electric motor efficiency.

Corner modules transmit data over the CAN bus, a robust method for various electrical components on the vehicle to communicate data with each other.



Testing our first corner module on our vehicle (2024).

2. The Opportunity of Data-Driven Design

In 2023, when the University of Toronto's Formula Racing team first introduced corner modules onto their vehicles, it was a significant step forward in **data-driven design**. In particular, the mechanical team based numerous design decisions on corner module data, including a redesign of the vehicle's shock absorption system.

For the 2024 season, we decided to implement corner module data acquisition to improve the vehicle further with regard to **tire health** and **electric motor behaviour**.

3. Objectives for Improving on 2023 Corner Modules

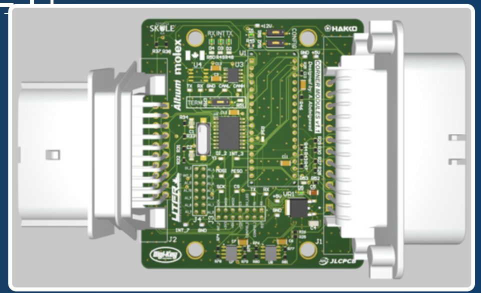
Compact
Reduce the size of each board without compromising circuitry.

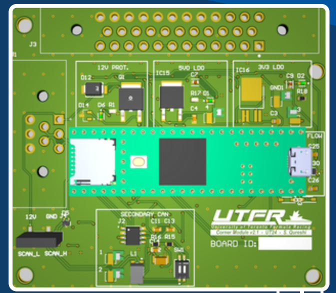
Versatile
Increase board compatibility with more types of vehicle sensors.

Durable
Design to withstand high turbulence, vibration, heat, and water.

UTFR
University of Toronto Formula Racing

2023





2024

2024 Improvements

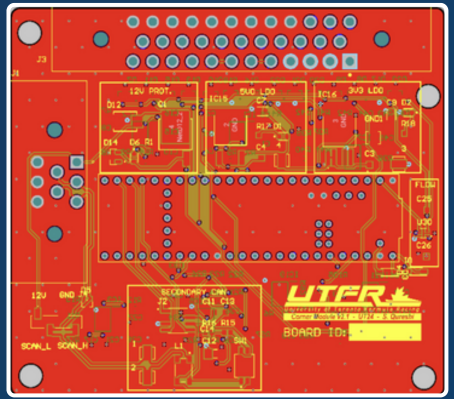
- **1000 mm²** reduction in surface area (roughly)
- **8** additional sensor connections for tires, brakes, and motors
- 3D-printed waterproof, shock-resistant cases

4. Design, Build, Validate

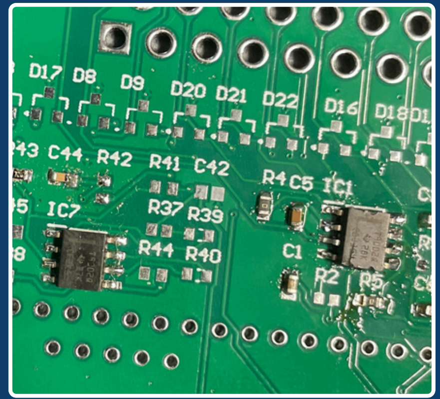
Corner modules went under two major design iterations. Components were selected based on circuit calculations.

Corner module boards and sensor connections were built and proxy-tested with simulation equipment.

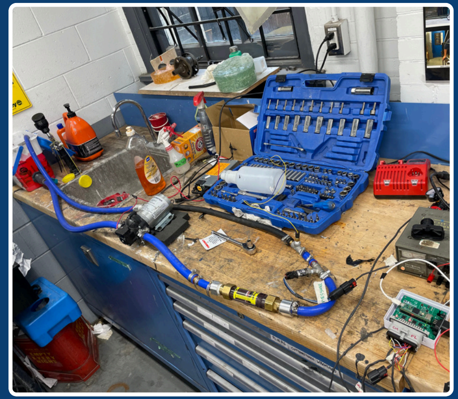
Hardware and firmware were validated on low-fidelity prototypes of specific vehicle systems.



First design iteration of the corner modules.

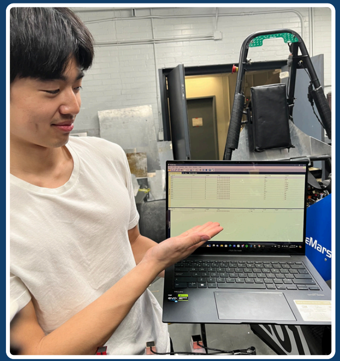


Electrical components being soldered onto the corner modules.



Hardware and firmware for retrieving motor data validated with mock motor system.

5. My Position



Corner modules successfully integrated onto the vehicle.

The integration of corner modules on the vehicle, despite being mainly an electrical project, would not have been possible without the extensive efforts from our team's mechanical division. I greatly emphasized **collaboration** and **learning**, as my teammates have guided me tremendously throughout my successes and failures.

Furthermore, I prioritized **validation** in my engineering design. By thoroughly testing each incremental development in the project, I verified that all elements functioned with high consistency. My extensive validation has provided my team with consistent and critical data.

Real-Time Tactile Feedback in Improving Bystander Cardiopulmonary Resuscitation (CPR) Quality

UNIVERSITY OF TORONTO

SEDlab SAFETY, EQUITY, & DESIGN

Allan Zhou[1,2], Joey Lu[1,3], Huda Musa[1,3], Hongchen (Flora) Liu[1,4], Deenar Virani[1,4] Supervisor: Professor Myrtede Alfred[1,4]

[1]Safety, Equity, and Design (SED) Lab, University of Toronto, [2]Division of Engineering Science, University of Toronto, [3]Division of Industrial Engineering, University of Toronto, [4]Department of Mechanical & Industrial Engineering, University of Toronto

Background

- **35 000 Canadians experience out of hospital cardiac arrests** (OHCA) **annually and only 1 in 10 survive.**[1]
- Performing immediate, high-quality CPR drastically increases survival rates, but many **untrained bystanders** perform incorrect and harmful CPR.[2]
- **High quality CPR** is defined by **compression rate, compression depth, and recoil**.
- Devices providing **auditory** and **visual feedback** have improved compression rate and depth[3], critical standards of CPR that bystanders often fail to meet.[4]

Objective

To evaluate the **effectiveness** and **usability** of our **multimodal CPR feedback device** on supporting bystander CPR quality.

Methods

Design

To evaluate the device's effectiveness and usability, we conducted a two trial counter-balanced experiment simulating OHCA on an adult manikin. We recruited 24 participants without current CPR certification. This study was approved by UofT REB (00046590).

Variables Assessed

- Compression Depth, Rate, and Recoil
- Set Up & Hands Off Time
- Support of Participant CPR

Analysis

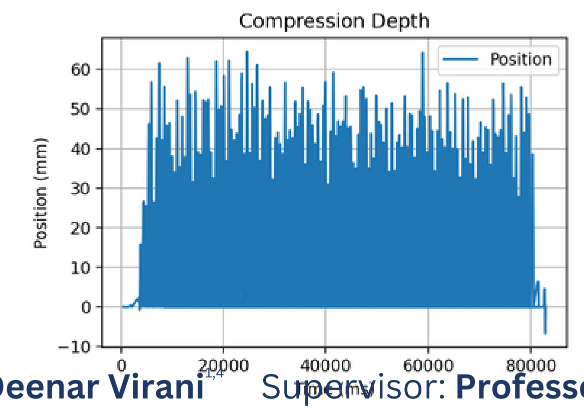
To determine device effectiveness, descriptive statistics and paired T-tests compared CPR quality data with and without feedback. For usability, a System Usability Scale (SUS) and qualitative feedback surveys were completed by participants.

Results

We conducted testing with 11 participants. From experience survey responses, 5 had performed CPR on a manikin/person and 2 had prior certifications.

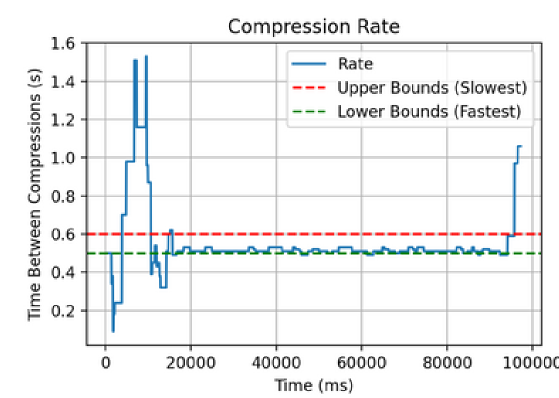
Haptic (Vibrational) Feedback & Compression Depth

- Short motor vibrations signaled compressions of adequate depth (50-60mm into the chest)[5].
- Chest compression fraction accuracy increased with use of feedback by 4.45%, but depth accuracy decreased slightly by 0.45%.
- 90.9% of participants found haptic feedback intuitive.

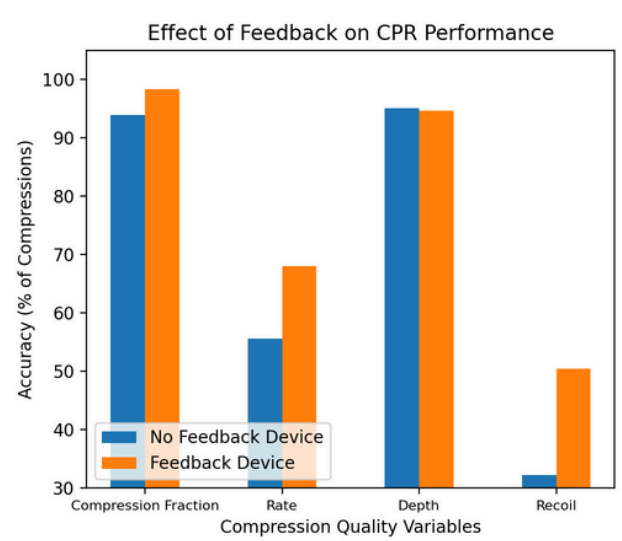


Auditory Feedback & Compression Rate

- Auditory feedback guiding participant compression rate provided every 6 seconds.
- Feedback improved consistency of compression rate (100/min to 120/min)[5], increasing accuracy by 12.45%.
- 72.7% of participants found auditory feedback intuitive.



Statistical and Qualitative Analysis of CPR Quality & Device Usability



Paired tests comparing CPR quality with and without feedback showed non-significant differences in Compression Fraction ($p=0.131$), Rate ($p=0.0766$), Depth ($p=0.721$), Recoil ($p=0.0525$), and Hands Off Time ($p=0.220$). Increasing sample size may provide clearer insights into the impact of feedback devices on CPR.

SUS Results

81.6 overall score[6] (SD = 8.16).

3.45/4 rating for ease of device usage (SD = 0.522).

3.00/4 rating for participant confidence in CPR during device use (SD = 0.894).

Qualitative Data

Audio and haptic feedback increased participant confidence and was comprehensive with the use of aid sheets, but many stated confusion and inconsistency with vibrations. Many found the device's structure to be uncomfortable when applying compressions.

Conclusion

- Auditory and haptic feedback shows promise in improving compression fraction, rate, and recoil.
- Feedback does not show significant potential in improving compression depth, possibly due to the additional force required for compressions with the device.
- Participants found the device quick to set up with the use of aid sheets, which may help reduce hands off time.
- Participants find the device intuitive and increases their confidence, but may be uncomfortable over 2 minutes of compressions.

Next Step

- Participants will continue to be recruited for the study to increase confidence of data analysis. The device will undergo design iterations based on the findings of the study.

Acknowledgements

This study was generously supported by the University of Toronto First Year Summer Research Fellowship Program and the Natural Sciences and Engineering Research Council of Canada (NSERC).

Thank you to the coauthors, Andreas Constas, Francesca Fortino, and our SED lab members for their contributions to this project.

1. Ehmann, M.R. et al. (2020). Journal of Healthcare Quality, 42(6): 326–332.
2. Hoeyweghen, R. et al. (1993). European Resuscitation Council, 26(1): 47–52.
3. Chen K-Y. et al. (2019). PLOS ONE, 14(2).
4. Alspach, G. (Ed.). (2005). American Association of Critical-Care Nurses, 25(6): 8-11.
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6. Brooke, J. (1996). ResearchGate, 189(194): 5-6.

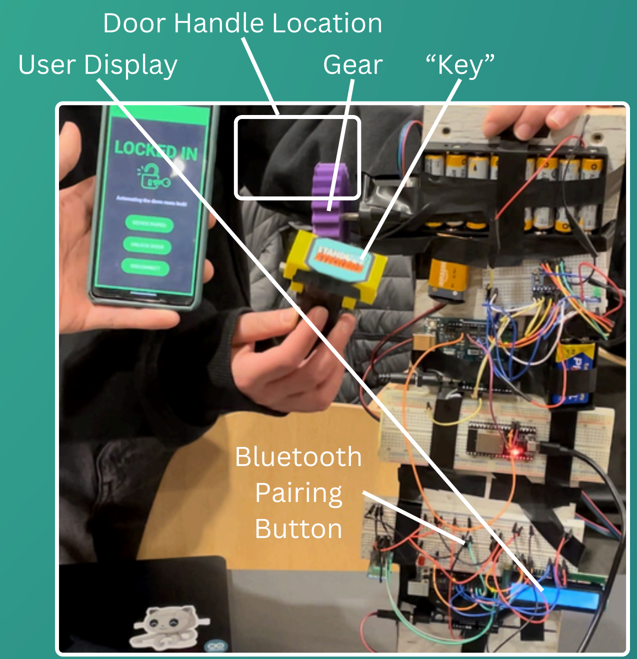
Locked In

An automatic door opener with custom mechanical components controlled by microcontrollers. Accessible via Bluetooth through an Android Studio app programmed in Java.

1. What is Locked In?

Locked In is a mechatronics project designed by Allan Zhou, Adam Omarali, Joseph Mi, and Jolyan Ye (EngSci 2T7) for MakeUofT 2024, a hackathon hosted by the University of Toronto.

Locked In is used to automatically open locked doors for users locked out of their residences. When new users wish to set up Locked In, they can pair their phone by pressing a button on the app and on the hardware to establish a Bluetooth connection. After Locked In recognizes the user's phone as a familiar device, they can control the gear that pushes the "key" to move the door handle whenever they are in close proximity to their door.



The hardware of Locked In being controlled by a custom app.

2. The Opportunity of Convenient Residence Life for Students

As undergraduate students, we are often short on two things: **time** and **money**. Locked In aims to help solve these problems.

By opening locked doors at the click of a button, students are spared the long hassle of taking off their backpacks, reaching into their bags, and pulling out their access cards. Furthermore, being locked out of your residence is a time-consuming and expensive experience. Not only does it take hours away from your studies, but it can be costly. In fact, CampusOne charges $40 for each access card replacement.

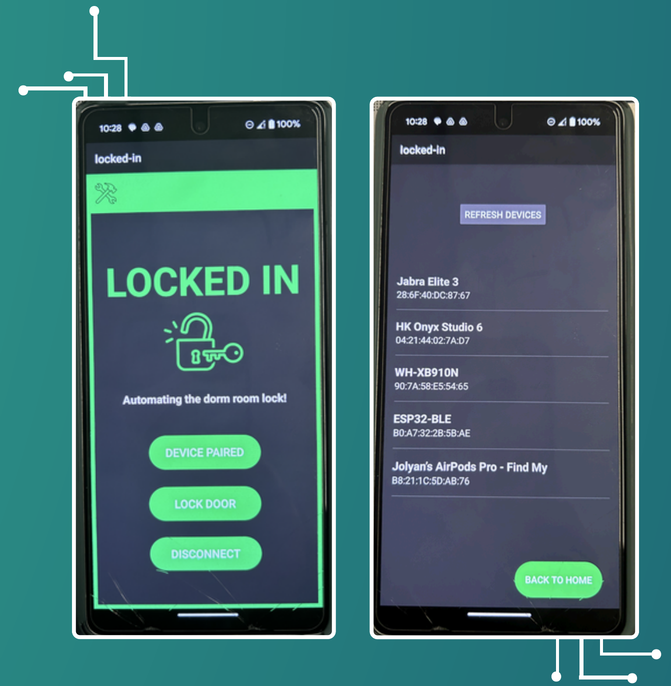
Campus One key card scanner.

3. Objectives for Locked In

User Friendly
Ensure users can set up and use the device without confusion.

Fast
Reduce the time it takes to unlock doors using remote devices.

Security
Prevent other people from accessing the device.



Features

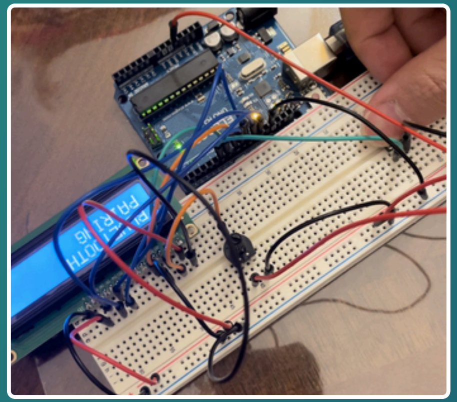
- **3 Button Interface** provides a simple user experience
- **Bluetooth Connection with Device** in less than **1 second** (based on 25 tests with phone 2.5 meters away from the device)
- **Manual Bluetooth Pairing** prevents unfamiliar devices from accessing Locked In

4. Rapid Diverging and Converging with Prototyping

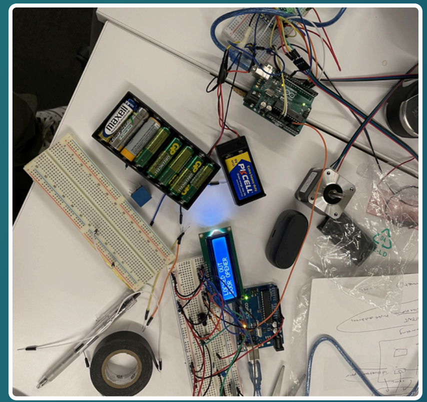
Several potential design concepts were demonstrated on prototypes to determine the feasibility of each idea.

We converged on a final design by combining our most consistently functioning design concepts.

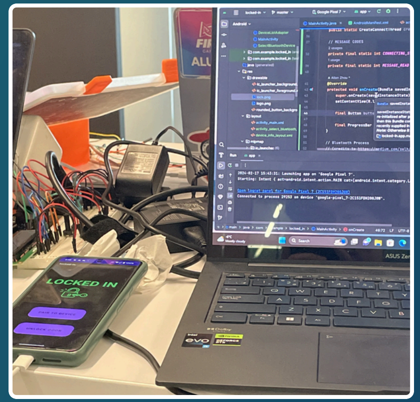
The integration of software and hardware required us to incrementally add functionality during testing.



Simulating Bluetooth pairing functionality on a low-fidelity prototype.

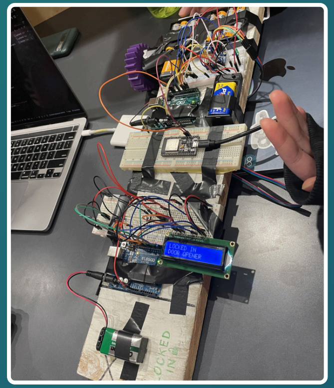


Combining our motor and Bluetooth pairing prototypes into our final design.



Hardware, firmware, and app software testing for Locked In.

5. My Position



Final prototype for Locked In.

Locked In pushed my **leadership** and **innovative** skills as we converged toward our final design.

Since automated door unlocking was my idea, I took the initiative to communicate my design ideas and guide my teammates in building the hardware and software. Coming out of the project, my team has gained critical skills for our development as engineers. Moreover, our solution to the opportunity encouraged us to draw from numerous fields of engineering, opening our minds to think of diverse and creative ideas.

No Stress, Maybe Strain

A bridge constructed from Matboard and Contact Cement designed to withstand over 400 newtons of weight from a train (CIV102).

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1. What is No Stress, Maybe Strain?

"No Stress, Maybe Strain" was a bridge designed by Allan Zhou, Alex Wang, Daniel Hong, and Joseph Mi (EngSci 2T7) participating in the CIV102 bridge design challenge. After being provided with an initial design for the bridge's cross-section, we worked with limited resources to optimize the amount of weight the bridge could hold. Bridges were constructed with Matboard, a cardboard-like material, and contact cement. Following construction, trains were rolled across our bridge until the bridge collapsed to assess the accuracy of the predicted load and maximum strength.

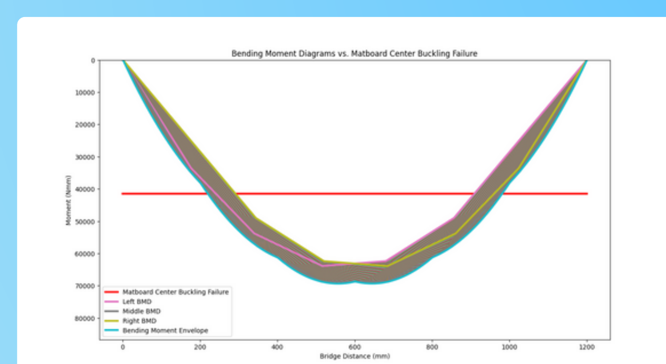
A 400 Newton model train being run over our final bridge design.

2. The Opportunity of Optimizing Strength with Limited Resources

With only 8260 cm² of matboard and 60 mL of contact cement available, we needed to design a bridge that would withstand various types of failures (buckling, shear, tensile, compression) caused by a rolling train.

Our final bridge design being left to dry.

Our team was able to frame two opportunities. Firstly, we determined a great need for automated calculations from custom software, as we could perform several iterations with more precision in significantly less time. Secondly, using our optimal bridge design, we aimed for high construction quality to fully demonstrate our bridge's features.



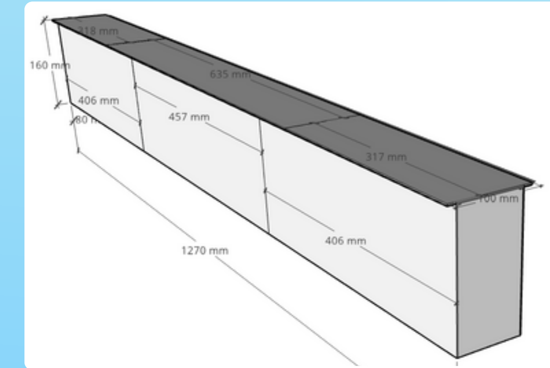
Visual data generated from our custom bridge software.

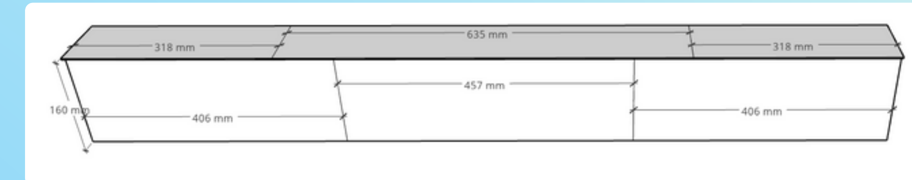
3. Objectives for No Stress, Maybe Strain

Strength
Maximize the amount of weight our bridge can hold.

Accurate Predicted Weight
Reduce the difference between theoretical and actual maximum load.

Quality of Construction
Ensure bridge construction does not compromise appearance and strength.



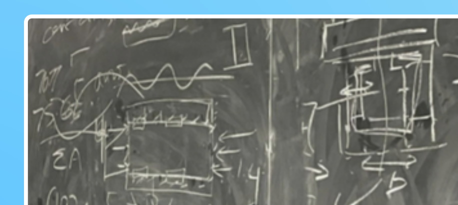


No Stress, Maybe Strain

- Theoretical maximum load of **1304 Newtons**

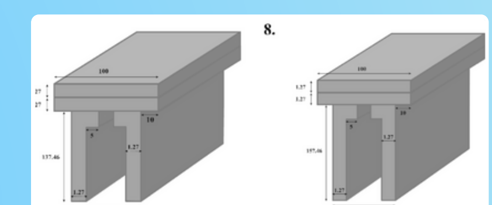
4. Framing, Diverging, Converging

To figure out the requirements for our solution, we approached bridge design from diverse perspectives.



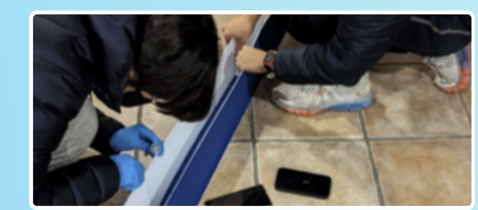
Determining which aspects of the bridge to prioritize through lightning ideation.

Using our custom bridge software, we iterated through designs to solve specific types of failure.



We went through 8 major design iterations based on our software's calculations.

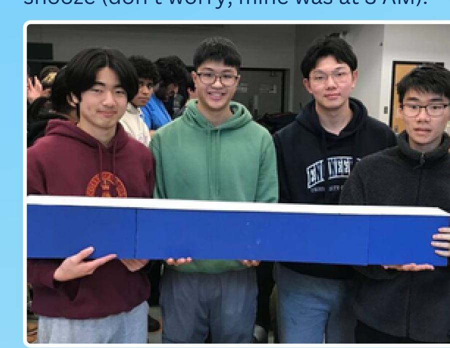
After combining two design iterations based on SCAMPER, we constructed our optimized final design.



Constructing our optimized bridge design.

5. My Position

Alex Wang's (not so) quick mid-build 2 AM snooze (don't worry, mine was at 3 AM).



No Stress, Maybe Strain on testing day.

"No Stress, Maybe Strain" unfortunately failed at 400 Newtons. However, I believe this was a **critical learning experience** for me as a growing engineer.

Firstly, my technical approach to problem-solving was correct in this scenario. By avoiding calculation errors and automating optimization, we saved lots of time in the long run.

Our greatest mistake was our quality of construction. By allocating more time to theoretical optimization, we had insufficient time to construct our bridge with high attention to detail, causing avoidable errors and extensive fatigue. This learning experience was essential in my future engineering projects, including **Corner Modules for Vehicle Data Acquisition**, as I have placed a greater emphasis on build quality and periodic breaks, leading to high-quality results.

Worm Wheel 360

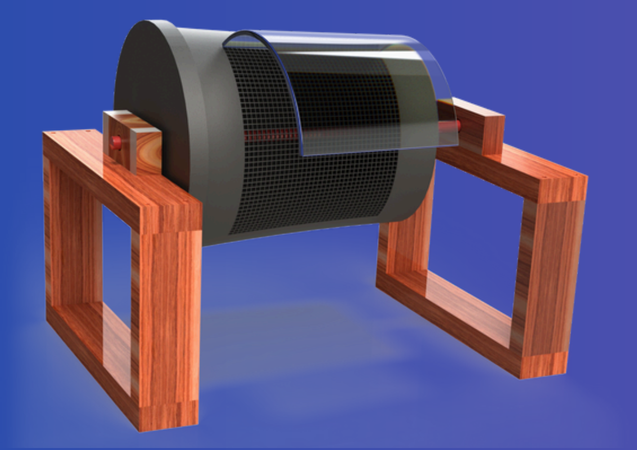
An effortless and efficient vermicomposting solution for reducing the amount of physical force required for quality gardening (ESC102).

Division of Engineering Science
UNIVERSITY OF TORONTO

1. What is Worm Wheel 360?

Worm Wheel 360 is a centrifugal rotator used for vermicomposting, which is the use of worms to turn organics into nutrient-rich worm castings.

The **Worm Wheel 360** allows for vermicomposting and soil filtering in the same place with removable flaps for placing and filtering soil. When gardeners wish to filter out worm-free soil, they can lightly spin the wheel and compost is quickly available.



The Worm Wheel 360.

2. The Opportunity of Reducing Physical Labour at Allan Gardens

From visiting Allan Garden and learning about their current vermicomposting solution, the stakeholders emphasized an annoyance with the great amount of physical effort required to lift heavy bins of vermicompost for long periods of time. Furthermore, the current process for vermicomposting is quite time-consuming, taking anywhere from 4 to 10 hours.

Our team sought to prioritize this stakeholder input throughout our diverging and converging, placing a great emphasis on creating an effortless and efficient design for the staff and volunteers and Allan Gardens.

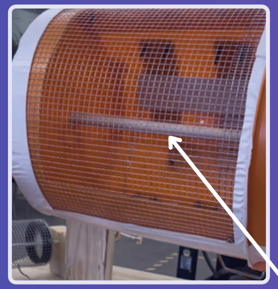
A staff member of Allan Garden's carrying a large, heavy bin of vermicompost.

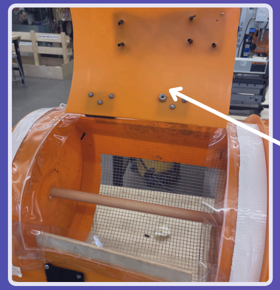
3. Objectives for Worm Wheel 360

Physical Effort
Reduce the effort needed to separate the worms from the soil.

Efficiency
Reduce the time needed to separate worms from the soil.

Worm Recovery
Ensure the safety of worms for future vermicomposting.





Features

- **360° rotating bin** for vermicomposting and easy worm removal
- **150°, 1/4 inch, replaceable mesh**
- **Mesh cover** for vermicomposting inside bin
- Smooth, low rotational friction **dowel**
- **Velcro flap** for soil addition and removal

4. Framing, Diverging, Converging

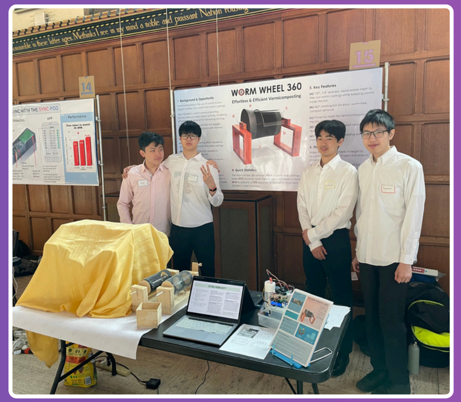
Our team visited Allan Gardens to interact with stakeholders and determine our opportunity.

Allan Garden's current solution of vermicomposting.

Prototyping a variety of solutions and performing proxy tests to determine the design's effectiveness.

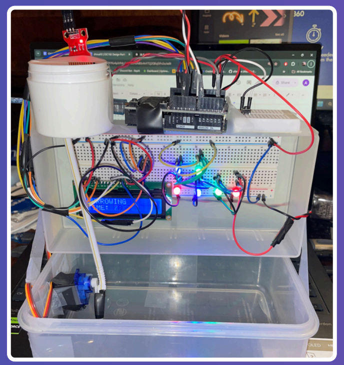
Using live worms safely and ethically to test our light and water solutions.

Presenting the Worm Wheel 360 at Showcase following the use of multiple converging tools.



Our team presentation at Showcase.

5. My Position



An initial mechatronic prototype for vermicomposting using light and water.

Leading up to the Worm Wheel 360, my biases resulted in me approaching the opportunity from a **purely technical standpoint**, resulting in a prototype involving complex technology. Although this solution met several critical requirements, I believe my biases caused me to initially overlook other stakeholder values of **durability** and **maintainability**, especially considering that the staff at Allan Gardens likely do not have technical backgrounds. I eventually discovered how this bias affected my engineering decisions in the project, leading to our team discarding the idea and converging on the Worm Wheel 360, a significantly better reflection of the stakeholder values.

Modular Accessibility Ramp

A versatile, weather-resistant solution to facility inaccessibility for students and staff of varying physical abilities (ESC101).

Division of Engineering Science
UNIVERSITY OF TORONTO

1. What is the Modular Accessibility Ramp?

The **Modular Accessibility Ramp** is a "kit-of-parts" ramp compatible with all facility entrances at the University of Toronto (St. George Campus). The various pieces in the ramp kit allow for a ramp of varying heights to be built while maintaining safety regulations enforced by the City of Toronto. Furthermore, the ramp is designed for usability under any weather conditions, particularly for rainy and snowy conditions.

2. The Opportunity of Accessibility and Safety on Campus

The University of Toronto student life estimates that over **4500 students** are registered with campus accessibility services -- a significant number of people who depend on accessibility aid between facilities.

From first-person observations, ramps at the University of Toronto suffered many structural shortcomings, including narrow width, small turning radius, improper construction, slippery surfaces, and inconvenient placement. Given the large number of facilities at the University of Toronto, a "one-size-fits-all" solution compatible with the different entrance sizes and heights would be extremely useful.

Wooden ramp on a rainy day outside the Earth Sciences Centre.

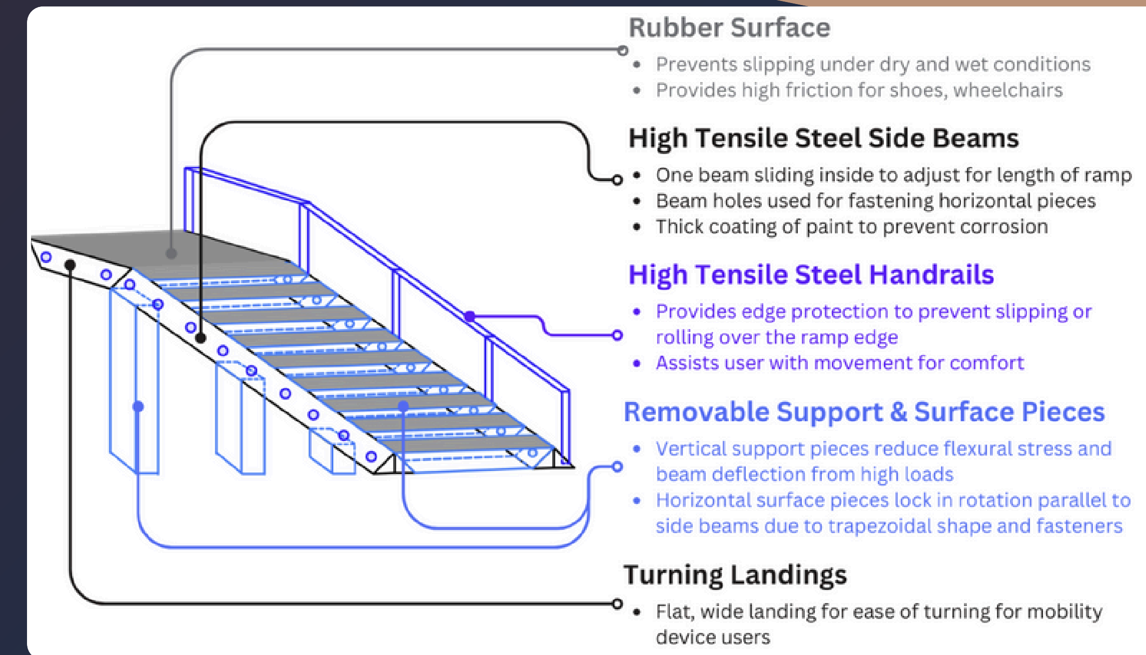
3. Objectives for the Modular Accessibility Ramp

Reliability
Prevent failure from heavy loads, varying weather conditions, and long-term use.

Usability
Ensure ramp can be conveniently used by stakeholders of all levels of physical ability.

Safety
Prevent slips and falls in any weather condition.

Versatile
Ensure design is compatible with entrances of varying heights.

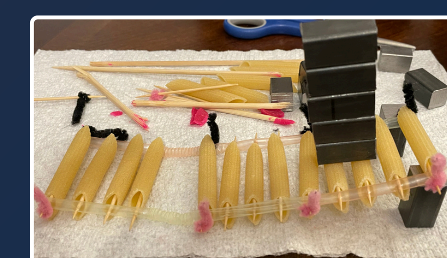


4. Framing, Diverging, Converging

To understand our opportunity further, we interacted with students using the ramps and took initial measurements.

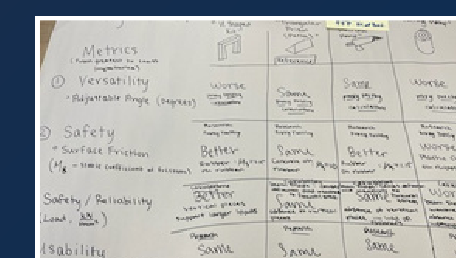
Measuring a ramp to determine whether its turning radius met city regulations.

We used the Lotus Blossom technique to brainstorm different designs which were eventually prototyped.



A prototype for a design concept using triangular shaped ramp pieces.

A Pugh Chart was used to converge towards our final design, a combination of previous design concepts.



Our Pugh Chart used to compare our top four designs based on our requirements.

5. My Position

My Praxis I team during Scavenger Hunt.

As I continued to work with new people during my introduction to university, it became apparent that more outspoken people had a greater influence on my group projects, a bias I had not fully understood until Praxis I.

The Modular Accessibility Ramp tested my abilities as a leader. Throughout studios and presentations, I developed an improved balance between speaking and actively listening, welcoming each member of our team to contribute to important discussions. This skill has been and will continue to be essential in all my engineering projects.