

# 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 (peptide synthesis company)

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

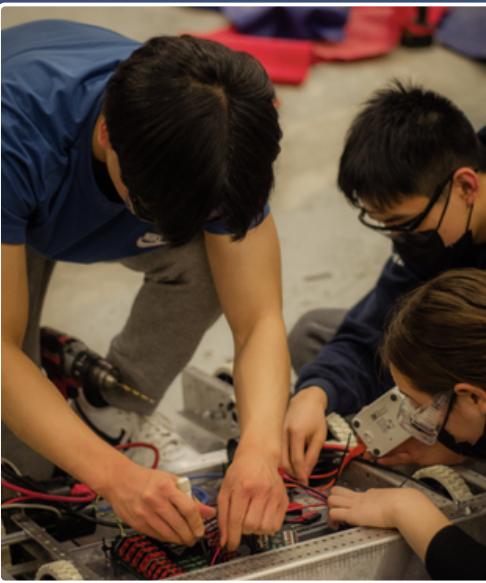
# My Practice of Engineering Design

## My Beliefs

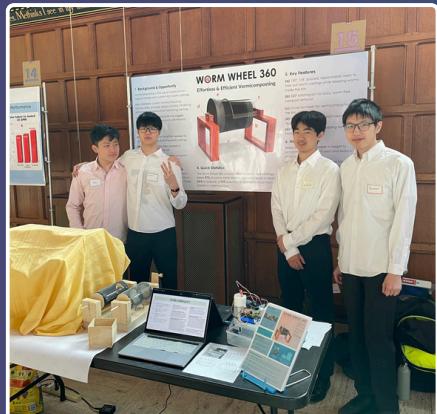
Engineering Design is the **balanced** process of creating solutions to achieve critical stakeholder objectives while being attractive to those interacting with the products.

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



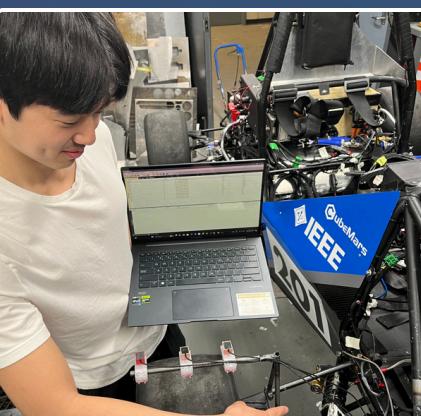
Collaboration



Learning



Leadership



Innovation

## My Perception

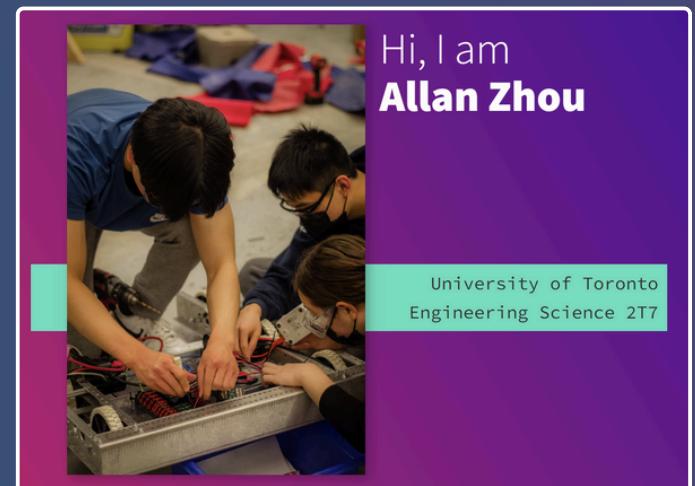
- As a leader who values strong communication, **more outspoken stakeholders** often have greater influence on my decisions
- I approach problems by emphasizing **logical and technical** solutions
- I believe inevitable failures must be learned from to **avoid similar future mistakes**



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/](https://allanlzee.github.io/allan.zhou/).



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

# Modular Accessibility Ramp

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

## 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.



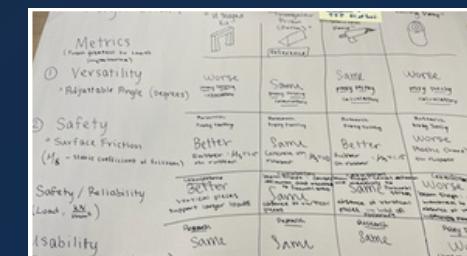
Measuring a ramp to determine whether its turning radius met city regulations.

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



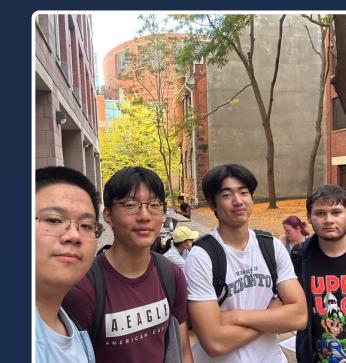
A prototype for a design concept using triangular shaped ramp pieces.

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.





# No Stress, Maybe Strain

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

## 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.



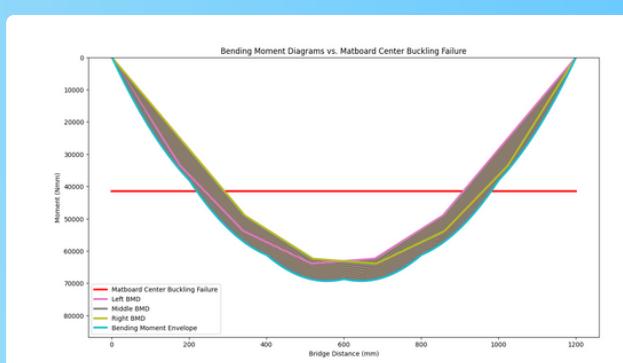
A 400 Newton model train being run over our final bridge design.

## 2. The Opportunity of Optimizing Strength with Limited Resources

With only 8260 cm<sup>2</sup> 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.



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.



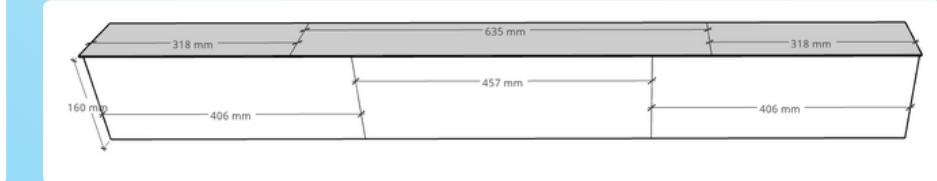
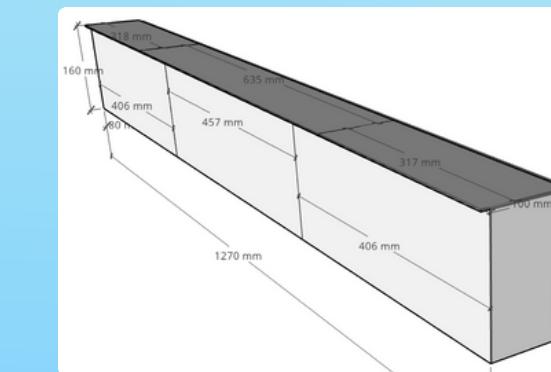
### Accurate Predicted Weight

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

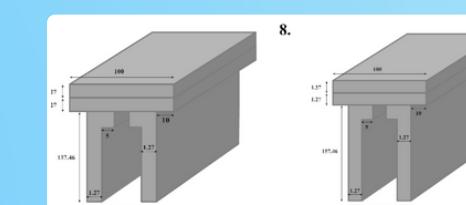
To figure out the requirements for our solution, we approached bridge design from diverse perspectives.

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

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



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



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



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.

# 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.

## 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.

## 3. Objectives for Locked In



### User Friendly

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



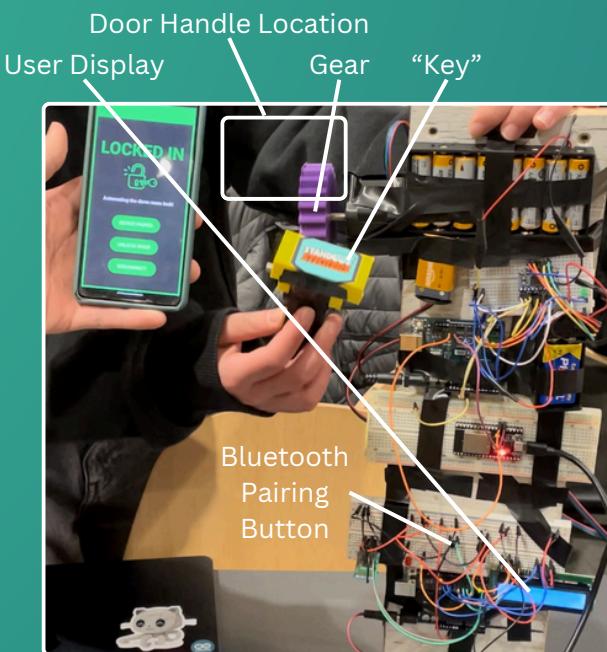
### Fast

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



### Security

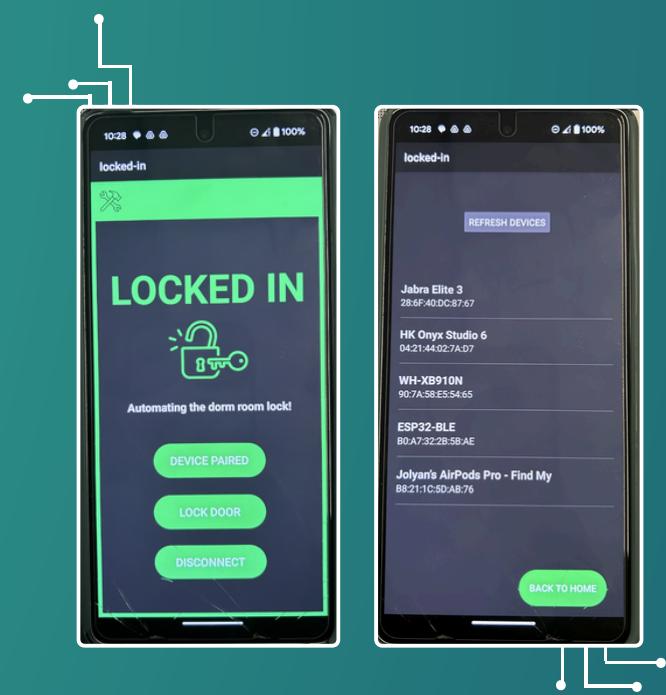
Prevent other people from accessing the device.



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



Campus One key card scanner.



## Features

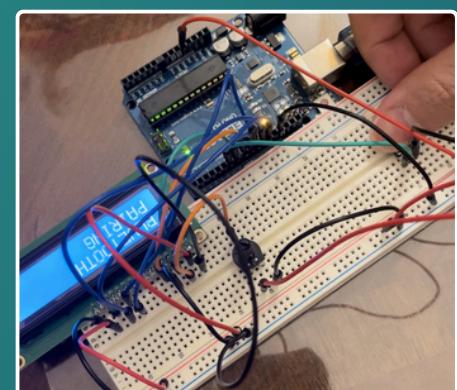
- **3 Button Interface** provides a simple user experience
- **Bluetooth Connection with Device** in less than **1 second** (based on 25 tests with phone 2.5 meters away from the device)
- **Manual Bluetooth Pairing** prevents unfamiliar devices from accessing **Locked In**



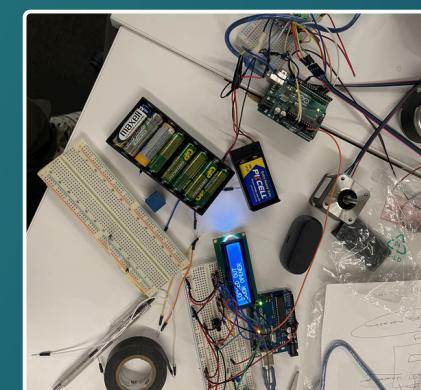
## 4. Rapid Diverging and Converging with Prototyping

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.

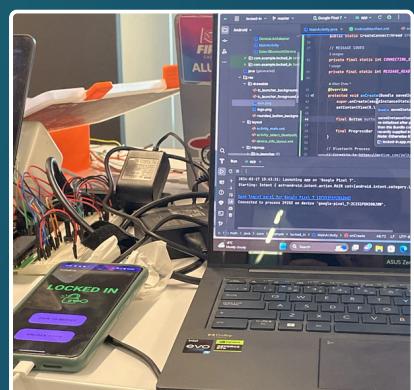


Simulating Bluetooth pairing functionality on a low-fidelity prototype.



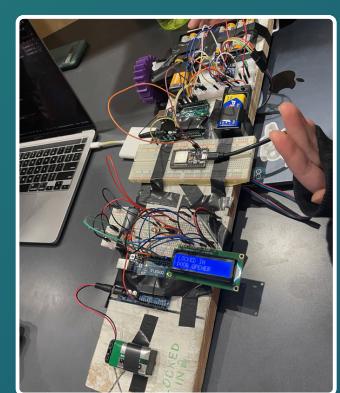
Combining our motor and Bluetooth pairing prototypes into our final design.

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



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.

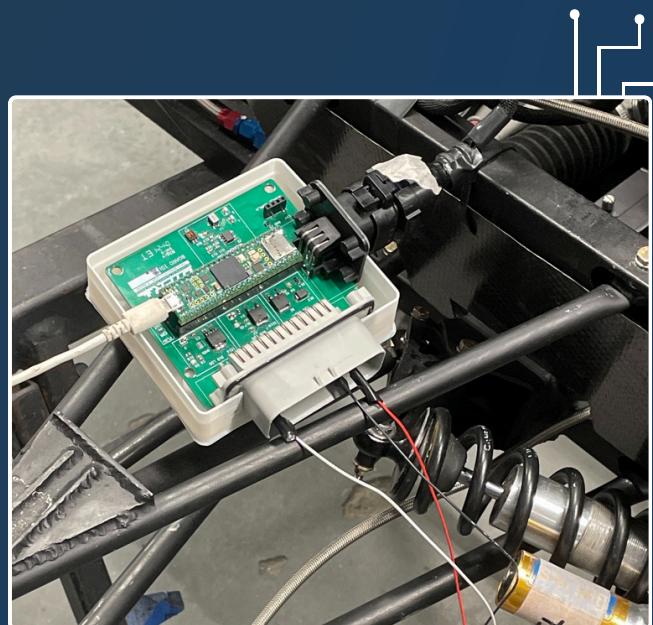
# Corner Modules for Vehicle Data Acquisition

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.

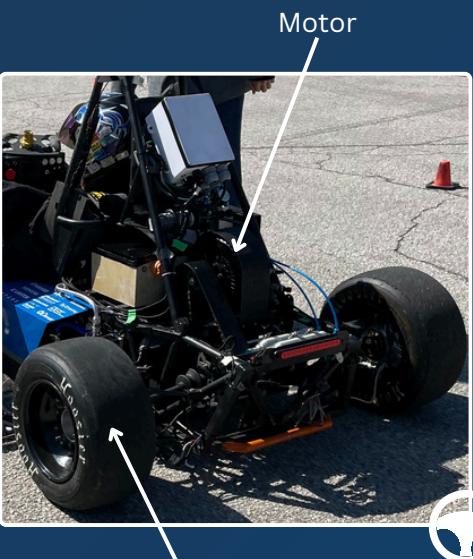


Testing our first corner module on our vehicle (2024).

## 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**.

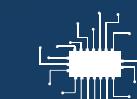


## 3. Objectives for Improving on 2023 Corner Modules



### Compact

Reduce the size of each board without compromising circuitry.



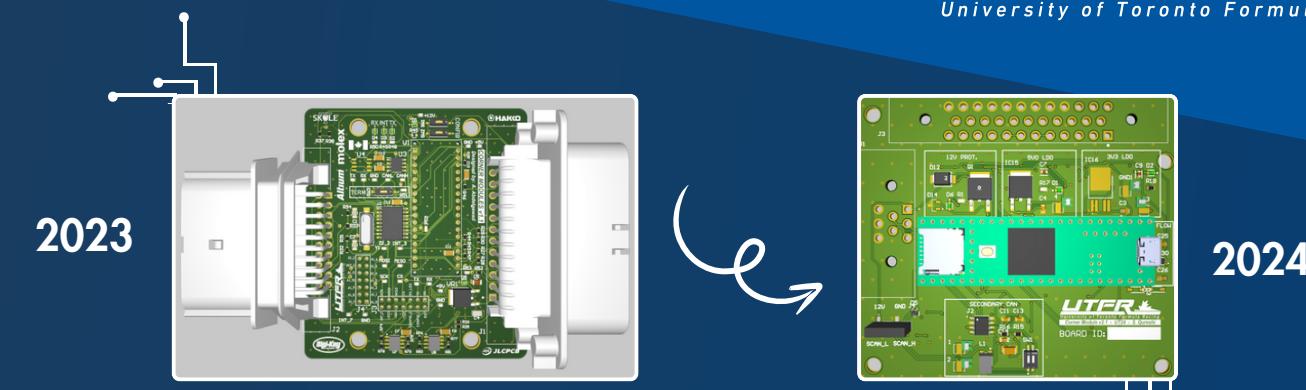
### Versatile

Increase board compatibility with more types of vehicle sensors.



### Durable

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



## 2024 Improvements

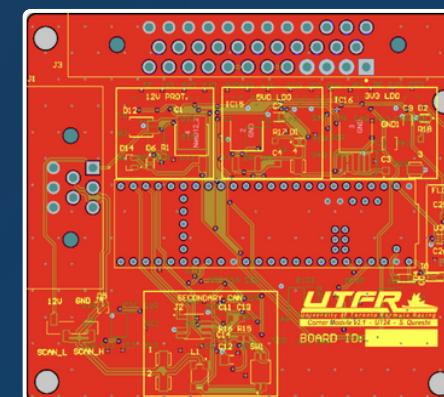
- **1000 mm<sup>2</sup>** reduction in surface area (roughly)
- 8 additional sensor connections for tires, brakes, and motors
- 3D-printed waterproof, shock-resistant cases

## 4. Design, Build, Validate

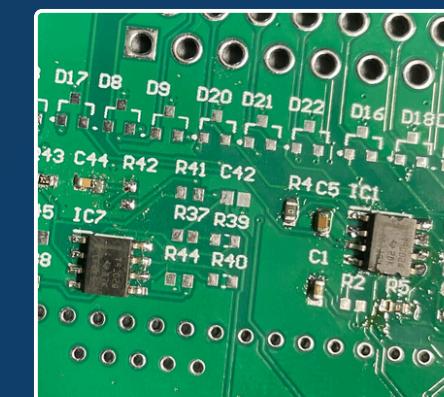
Corner modules went under two major design iterations. Components were selected based on circuit calculations.

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

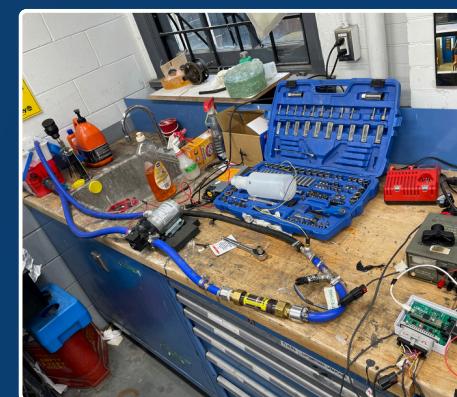
Hardware and firmware were validated on low-fidelity prototypes of specific vehicle systems.



First design iteration of the corner modules.

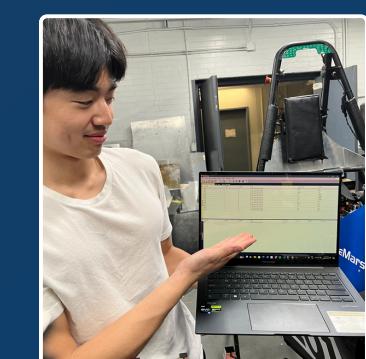


Electrical components being soldered onto the corner modules.



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.



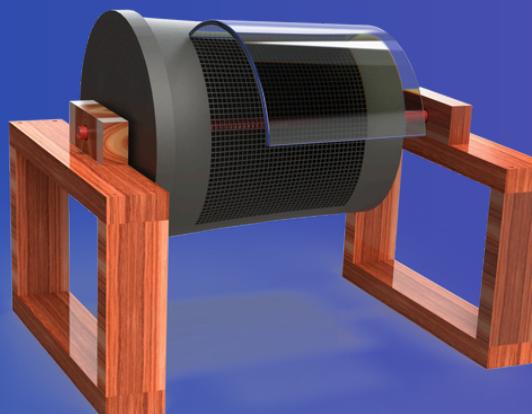
# Worm Wheel 360

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

## 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 at 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 Garden to interact with stakeholders and determine our opportunity.

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

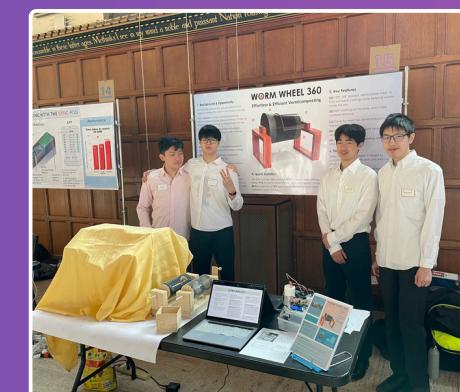


Allan Garden's current solution of vermicomposting.



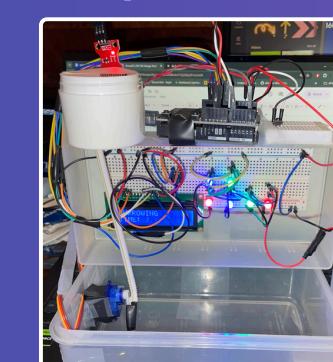
Using live worms safely and ethically to test our light and water solutions.

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.



**Thank you for reading my  
design portfolio!**

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