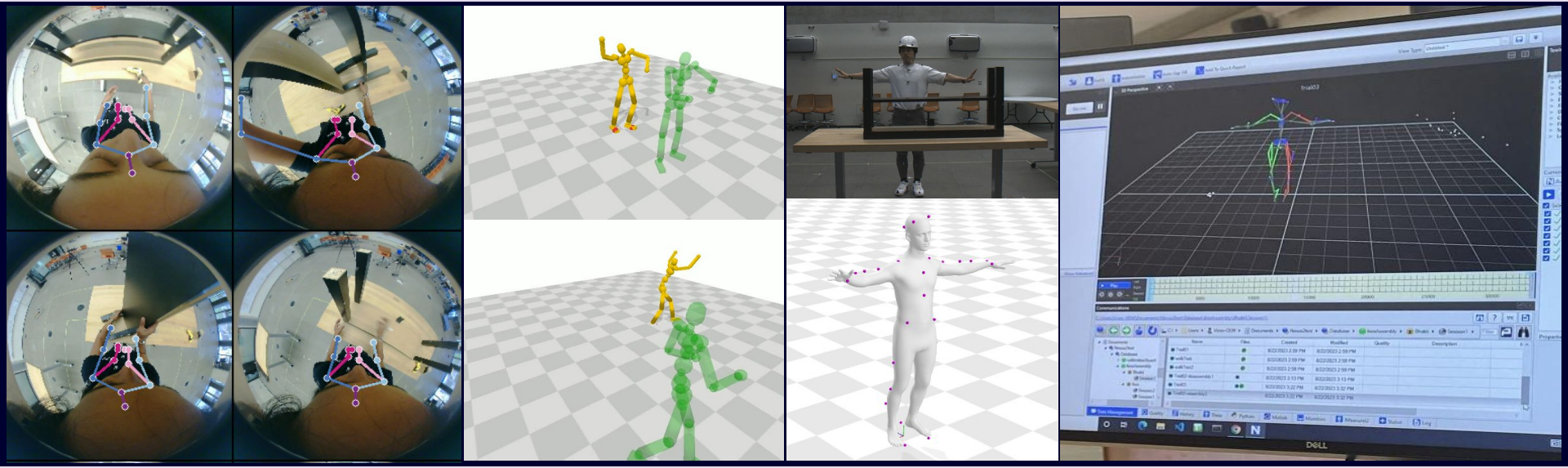
Engineering Design Portfolio

Bhakti Chohan

Visual Simultaneous Localization and Mapping (SLAM): pt1

May 2023 - Present



Description

Collaborative research project with Nissan developing a dynamic model for Visual Simultaneous Localization and Mapping (SLAM). The model is intended to improve manual assembly processes of automobiles at industrial plants. Using the VICON motion capture system and the cutting-edge Nexus2 modeling tool software to track human motion, we reconstructed human body parameters with accurately synchronized IMU sensors, 360 degree cameras, and StereoVision cameras. We have a research paper in work.

References:

Scene-aware Egocentric 3D Human Pose Estimation

BodySlam: Joint Camera Localisation, Mapping, and Human Motion Tracking

Visual Simultaneous Localization and Mapping (SLAM): pt2

May 2023 - Present

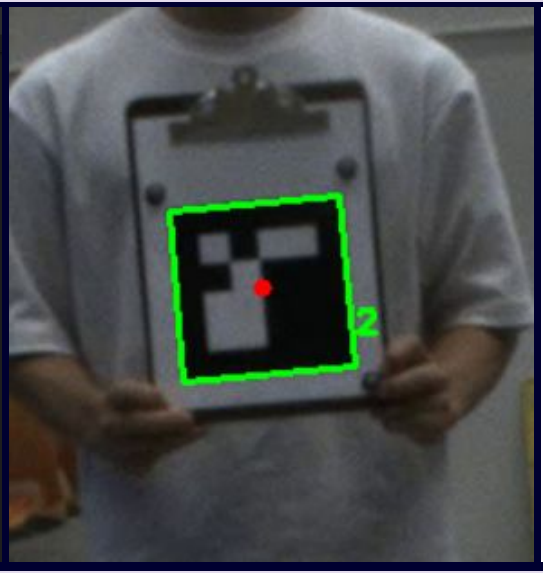
arucotag_detection.py | arucotag_tvecs.py | viconCamera_translation | viconCamera_translation.py | visualize-c3d.py

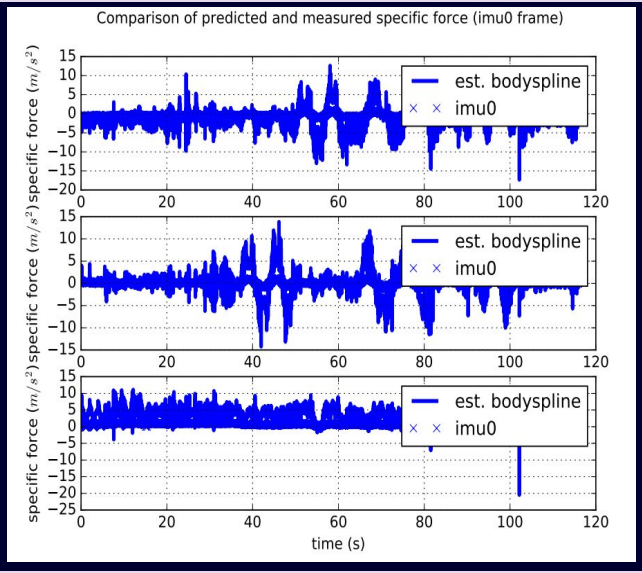
allCamera-calibration > 20230616- data > viconCamera_translation > find_row

```
vicon_pd = pd.read_csv('C:/Users/hp/Documents/STARS Lab/allCamera-calibration/vicon_tvecs.csv')
aprilgrid_pd = pd.read_csv('C:/Users/hp/Documents/STARS Lab/allCamera-calibration/aprilgrid_tvecs.csv')
vicon_arr = vicon_pd.to_numpy()
aprilgrid_arr = aprilgrid_pd.to_numpy()
# print(vicon_arr)

def draw_registration_result(source, target, transformation):
    source_temp = copy.deepcopy(source)
    target_temp = copy.deepcopy(target)
    source_temp.paint_uniform_color([1, 0.706, 0])
    target_temp.paint_uniform_color([0, 0.651, 0.929])
    source_temp.transform(transformation)
    open3d.visualization.draw_geometries([source_temp, target_temp],
                                         zoom=0.4559,
                                         front=[0.6452, -0.3036, -0.7011],
                                         lookat=[1.9892, 2.0208, 1.8945],
                                         up=[-0.2779, -0.9482, 0.1556])

vicon_pcd = open3d.geometry.PointCloud()
vicon_pcd.points = open3d.utility.Vector3dVector(vicon_arr)
SFM_SCALE = 5
aprilgrid_pcd = open3d.geometry.PointCloud()
aprilgrid_pcd.points = open3d.utility.Vector3dVector(aprilgrid_arr * SFM_SCALE)
# threshold = 0.02
threshold = 20
# threshold = 999999
trans_init = np.eye(4)
estimation_method = open3d.pipelines.registration.TransformationEstimationPointToPoint(with_scaling=True)
reg_p2p = open3d.pipelines.registration.registration_icp(
    aprilgrid_pcd, vicon_pcd, threshold, trans_init,
    estimation_method)
draw_registration_result(aprilgrid_pcd, vicon_pcd, reg_p2p.transformation)
```





Role

Developed code for calibration using Aprilgrid and ArUco marker recognition to obtain relevant translation (tvecs) and rotation (rvecs) vectors for reference frame calibration between the vicon software and respective recording cameras. Developed using Linux commands, Docker commands, and programming in ROS2. Wrote code for real time visualization of c3d data from ROS2 topics collected through the VICON system, and analyzed data during the post-processing stage using error algorithms on docker.

Launch Rail

May 2022 - Present




Description

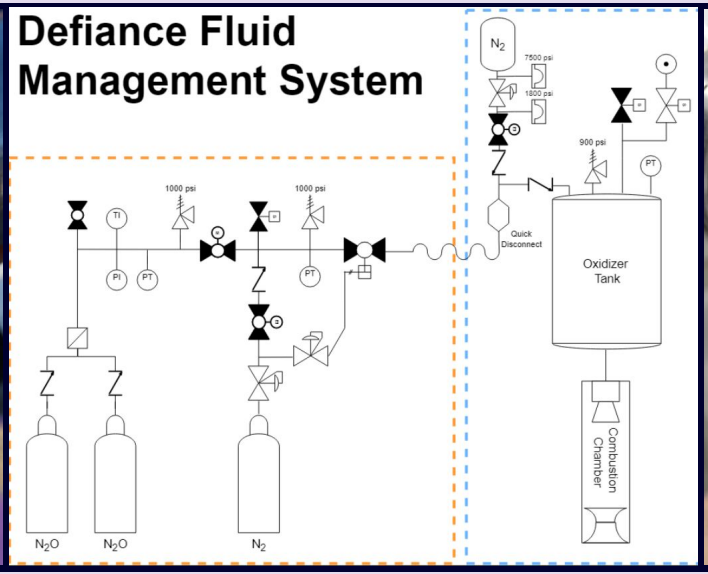
Used to hold the rocket vertical during the remote fill process, stabilize the rocket until it has sufficient speed where enough aerodynamic force is generated by fins to keep trajectory straight, and direct the rocket to an appropriate angle guided by the LSO before launch. The launch rail is 32 feet tall, can withstand 10kN of blast thrust force, and is designed for Assembly and Reliability.

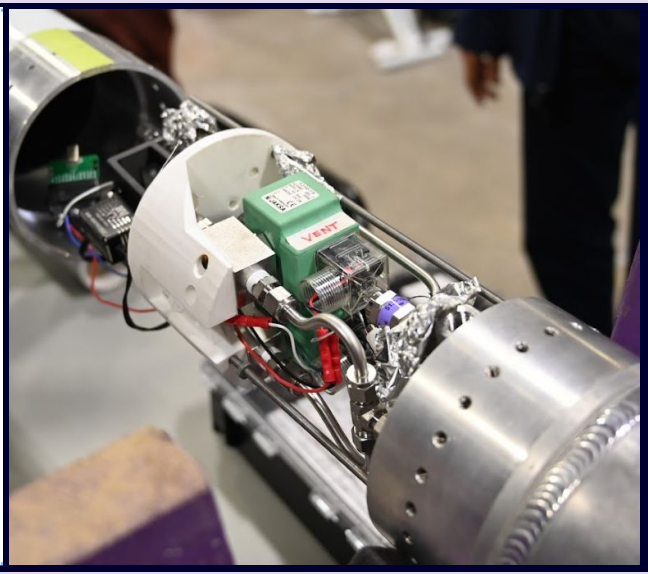
Role

Fabricated, tested and assembled rail in preparation for and during launch. Added truss supports to previous design to create a stiffer launch rail to support the 7kN thrust force of our hybrid rocket (as seen in pictures). Was chiefly responsible for the redesign of launch base to make it more sturdy and robust, and the addition of a lever arm to support easier and safer lifting of the launch rail. Additionally, writing the testing and assembly procedure documents for Launch Canada 2023.

Hybrid Rocket Engine Oxidizer and Pressurent Management System

September 2023 - Present





Description

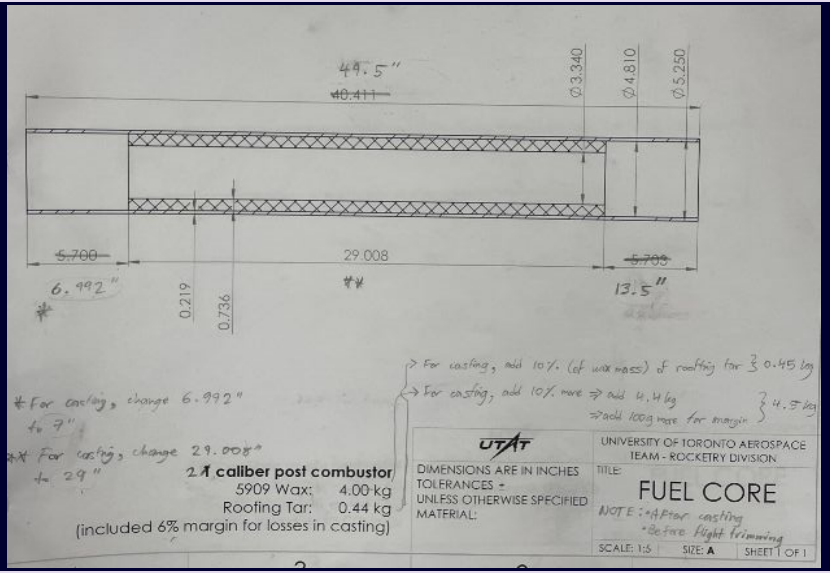
The management system routes fluids from their K-Tank storage vessels to the rocket's oxidizer tank at the desired fill rate and pressure. The rocket uses a top-fill method while under high-pressure Nitrogen gas intended breach the decomposition pressure of liquid Nitrous oxide; the Nitrous Oxide gradually replaced the Nitrogen gas until fill with ullage is achieved. The system is engineered with single fault tolerance and redundancy in all critical purge valves and pressure reading equipment.

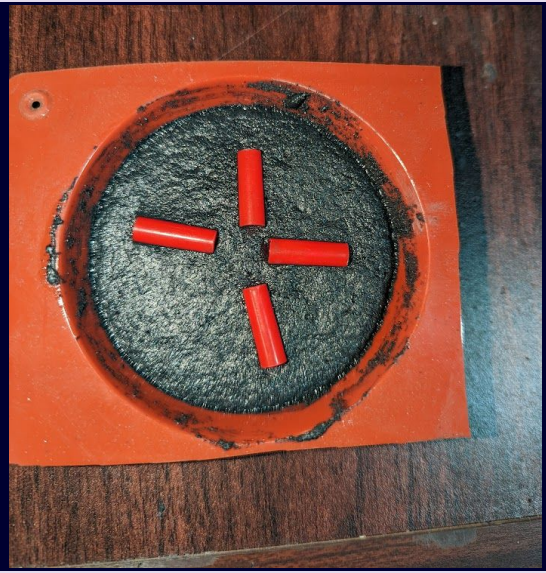
Role

Spearheading the evaluation and redesign of the system for Launch Canada 2024. Leading testing and fill operations during cold flows and hotfires, part-sourcing and manufacturing for the assembly and integration of ground-based fill hub and rocket-based fill bay on Defiance Mk IV.

Hybrid Rocket Solid Fuel Composition and Ignition System

September 2023 - Present





Description

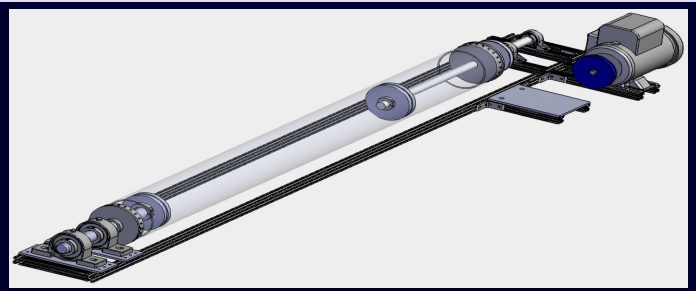
In a hybrid rocket engine, solid fuel mixes and combusts with liquid oxidizer to generate high velocity exhaust gas and propel the rocket. We create our own solid fuel cores from high purity microcrystalline paraffin wax and an opacifying agent to ensure an even burn. In order to start the combustion reaction, we create and use pyrodex-based ignitor cakes to burn through mylar burst discs which serve as our main oxidizer valve.

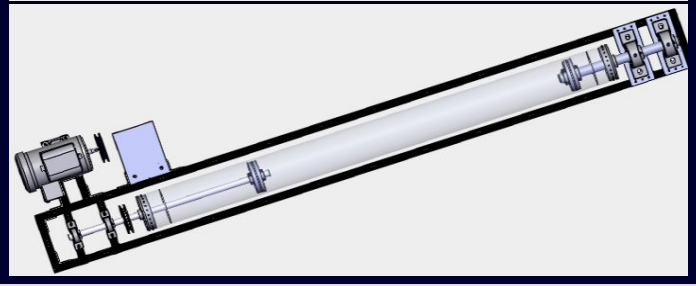
Role

Leading the experimentation and refinement of our fuel composition and manufacturing techniques. Notably, I intend to replace roofing tar with much higher purity Carbon Black powder to decrease grain size and increase combustion efficiency. To improve reliability of our igniters (which have caused failure in the past), I will research igniters and perform various tests to make the ignition system more reliable for the team.

Fuel Core Spin Caster

May 2022 - Present





Description

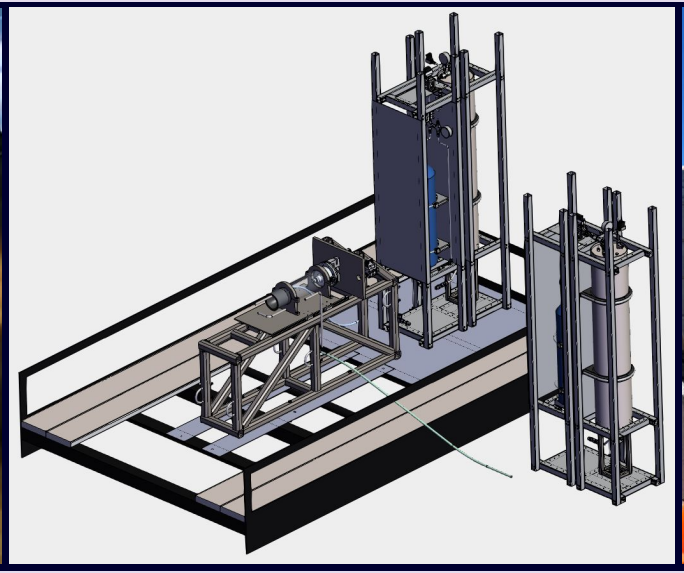
UTAT's hybrid rocket uses paraffin wax as its solid fuel. Using the spin caster, paraffin wax is cast into a cylindrical tube to fit inside the combustion chamber of the rocket. The system contains a spinning bulkhead that moves lengthwise within the tube, and uses centrifugal force to distribute wax evenly and cast a hollow solid fuel core. Runs at 2300 rpm using an 420cc gas engine.

Role

Oversaw the redesign of the spin caster: optimized the existing assembly to make the system more efficient, machined and outsourced parts for replacements, replaced the electric motor in the assembly with an engine to run system at a higher rpm for a longer time, and designed a better attachment mechanism to the base for better absorption of vibrations when in use. Casted 6 cores this summer for rocket engine tests and flight.

Test Stand

Sept 2022 - Present



Description

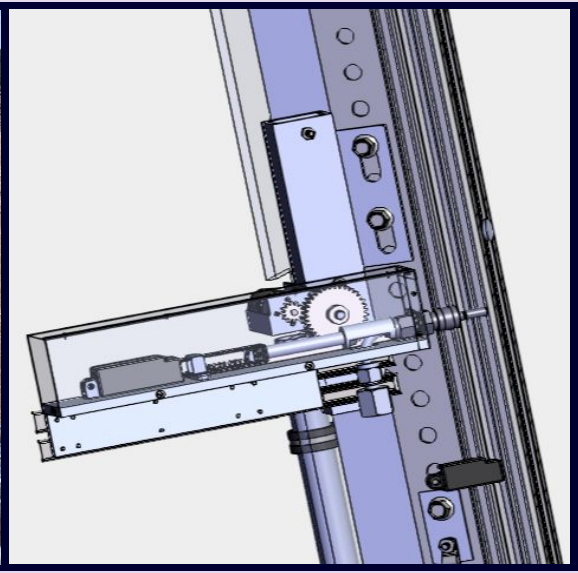
The propulsion testing facility (test stand) is used to support testing campaigns for UTAT's engine cold flows and rocket engine fire tests. It is used to practise fill-bay fill procedure and processes, and demonstrate the capacity to measure maximum blast force produced by engine using load cells precisely placed (can withstand upto 30 kN). Work with liquid propulsion division to meet requirements and deadlines.

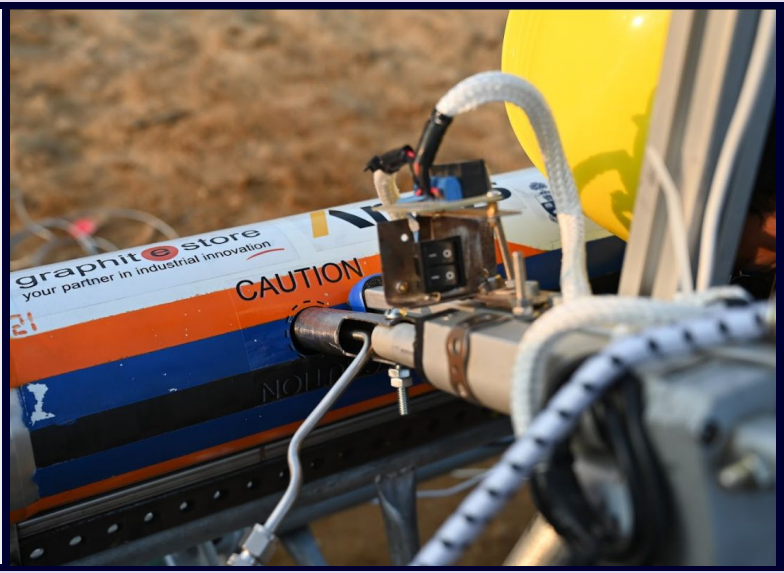
Previous Role

Supported the assembly and set up procedure before cold flows and hot-fire tests. Oversaw the redesign of the test stand to support our new liquid rocket: adjusting the length of combustion chamber holder to support the reduced length of the liquid engine, and adding an additional tank holder to the test stand for liquid rocket (as seen in CAD).

Quick Disconnect

May 2022 - Present





Description

Used to automatically load liquid propellent into the rocket remotely just before launch using ground station equipment. Uses two linear actuators and supporting circuitry to attach to quick disconnect coupling present inside the rocket. Has a detachment period of 1.2 seconds.

Previous Role

Fabricated, tested and assembled in preparation for and during launch. Added functionality for accuracy by performing accurate calibration right before launch. Credit: Original gear box design (as seen in CAD) was design by previous members, this design was changed during testing.

Current Role

Overseeing the redesign of extended arms to make it more sturdy, the replacement of a new coupling to support an accurate and reliable fill process before launch, and the addition of functionality by allowing for live z-axis correction. Additionally, writing the testing and assembly procedure documents for Launch Canada 2023.

Launch Canada Competition 2023

August 2023

Description

Represented the University of Toronto Aerospace Team at the Launch Canada 2023 competition in Ontario, Canada. Placed Third in the Advanced Category.

Role

Led the structures division for the set-up of our ground-supporting equipment, including launch rail assembly, quick disconnect assembly and integration, and load cell calibration and integration. As a propulsion member, I helped with rocket engine assembly and pressurent system testing. Unfortunately, due to an engine ignition failure, the team ended up not launching our hybrid rocket, however, we all learned how to work in a team in a high-pressure environment. The team will continue development on our hybrid rocket to fix issues and practise a seamless launch for next summer!

Launch Canada Competition 2022

August 2022

Description

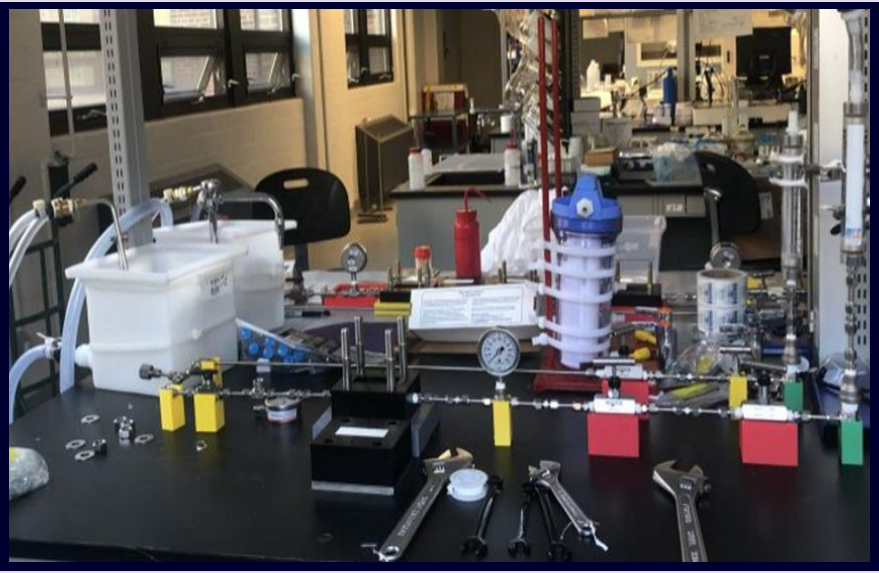
Represented the University of Toronto Aerospace Team at the inaugural Launch Canada competition in Ontario, Canada. Flew Canada's first experimental (not COTS) hybrid-propulsion rocket to 23,000 feet to Mach 1.2. Placed First in the Advanced Category. Heavy timeline-dependence and quick-moving hands-on work on the field.

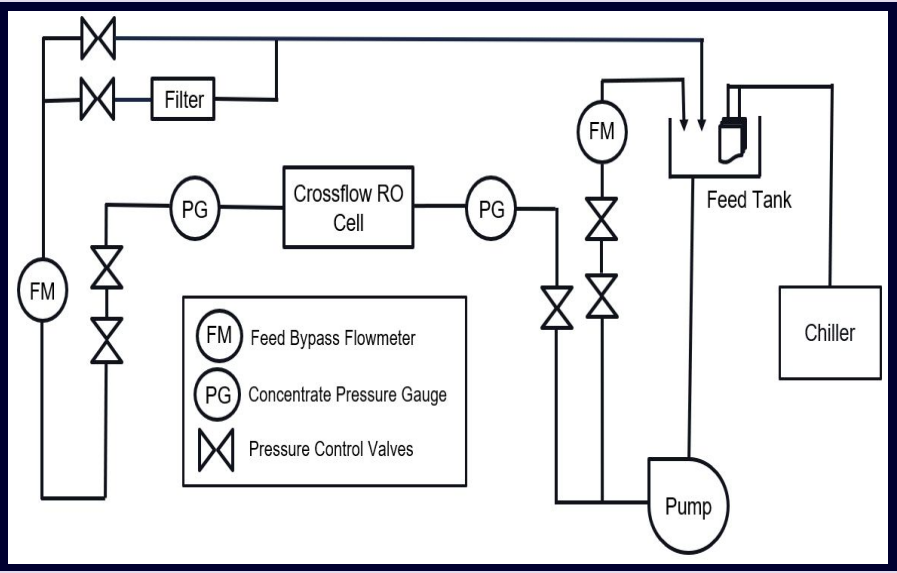
Role

As the lead of the structures division, Led the set-up of ground supporting infrastructure including the launch rail assembly, quick disconnect integration, antennas, and liquid fuel tanks. Learned to work under pressure in high-stress and atypical environments, pushed forward with teammates to develop skills and experience in the field. Spoke with multiple industry professionals and gained new outlooks on our developments.

High Pressure Reverse Osmosis System

May - August 2022





Description

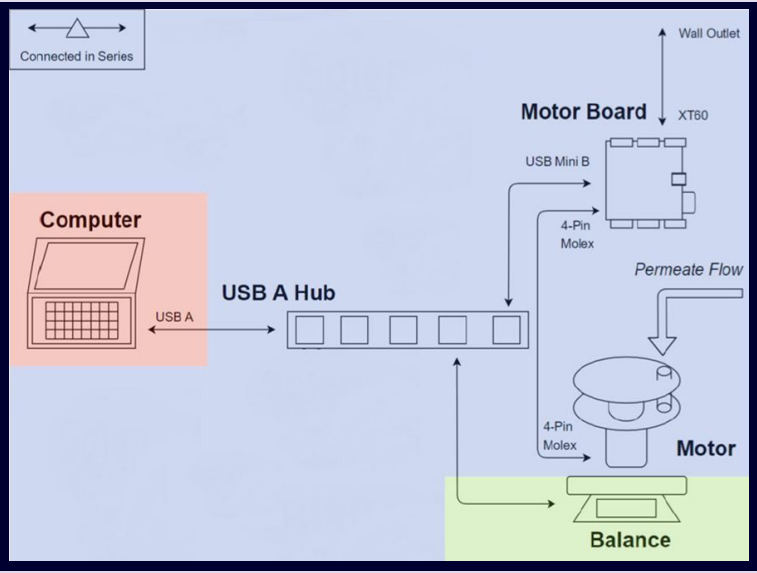
Optimized and assembled a bench-scale high-pressure reverse osmosis system capable of pressures up to 150 bar, will be used to test the selectivity and water permeability of membranes developed within the lab. Uses a high powered pump, chiller, pressure gauges, pressure control valves, and a in-house machined crossflow RO cell setup (see in system diagram). CAD and 3D printing was a big part of the project.

Role

Tasked with ordering all relevant parts of the system, fabricating + machining relevant RO cells for testing, optimized parts of the system for efficiency (achieved 15% more optimization), CADed and 3D-printed relevant supports for components to sit on to ensure equal height for the system to sit on, and finally assembled full high pressure system within the lab in 3 months (as seen in the picture). System considerations included the use of pressure components rated 170 bar and PTFE tape to maintain a hard seal. Credit: The design for the system was inspired by a research design paper found online.

Auto Sampling System

May - August 2022



Description

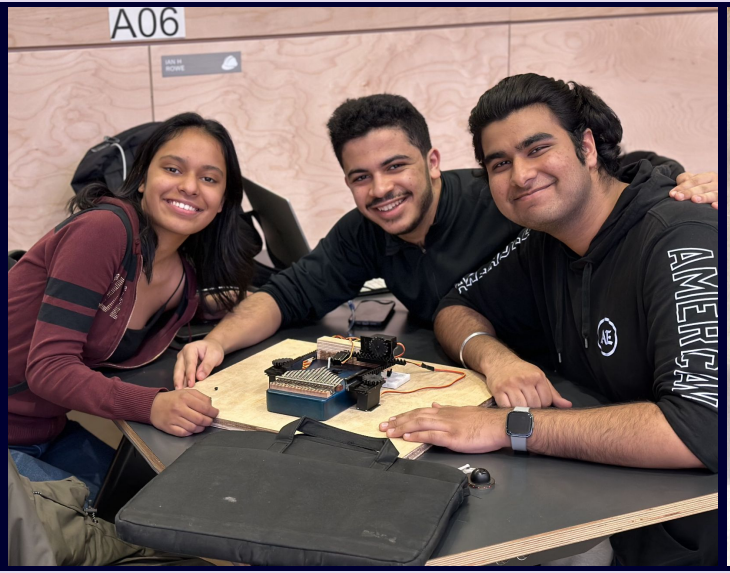
The system is intended to automate the collection of samples at a desired user-input mass for ongoing chemical reactions in the lab. It is comprised of a servo motor, motor board, and mass balance, each controlled via a custom GUI user interface, which is also a custom in-house code design.

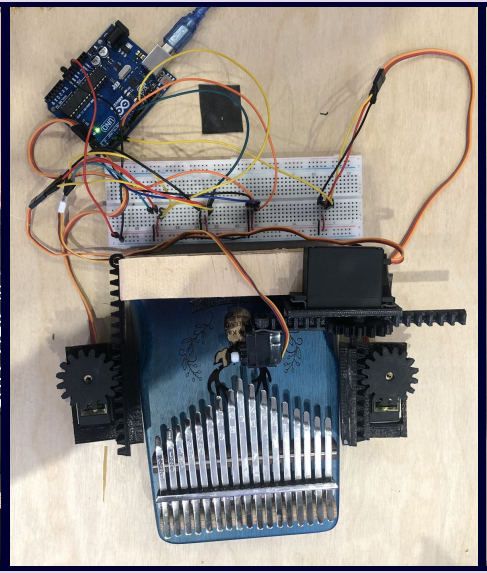
Role

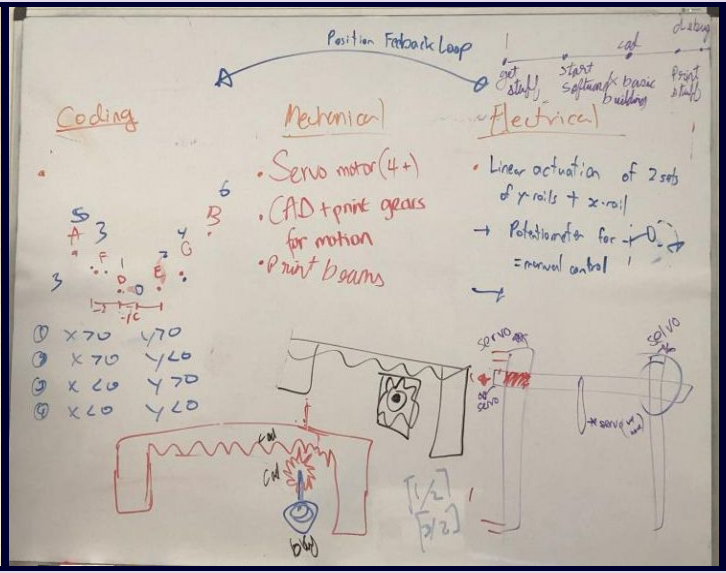
I had full autonomy over the design and integration of the system. Involved ordering all relevant electrical components, writing and testing GUI code with integration of the servo motor, CADing and 3D-printing necessary structural components. The system allowed lab members to save 4+ hours of work by eliminating the need for user to spend the day next to reaction in order to take samples at different intervals. System considerations included allowing for different types of chemical reactions taking place, letting user choose servo rotation based on mass or time iterations. Credit: The design for the system was inspired by a supporting lab's research design paper.

Automated Kalimba Player (Make-A-Thon Event)

February 2023







Description

A hack-a-thon like event where we had 24 hours to design and build a physical system in the category of music. We automated music playing on the Kalimba instrument. We divided our project into 3 subsystems: software, electrical, and mechanical. Our design process involved iterative brainstorming and design, and no shortage of quick-thinking due to our time constraint. This was an incredibly fun experience with my friends and I look forward to taking part in more design competitions in the future.

Role

I was responsible for our mechanical system: composed of two y-axis servos, one mobile servo that moves with the y-axis to guide the x-axis, and an additional rotary servo that flexes particular Kalimba tines to create the sound. Gears were attached to the servos to simulate a linear actuator system which was then guided by the code. Within this system, I CADed the mechanical and structural components, and 3-D printed them using simple PLA filament.

High Powered Rocketry (Level 1 Rocket Launch Certification)

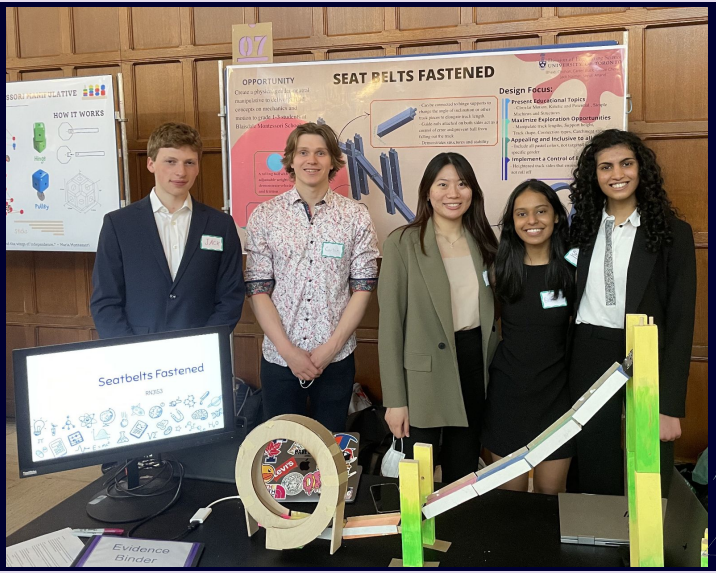
July 2022

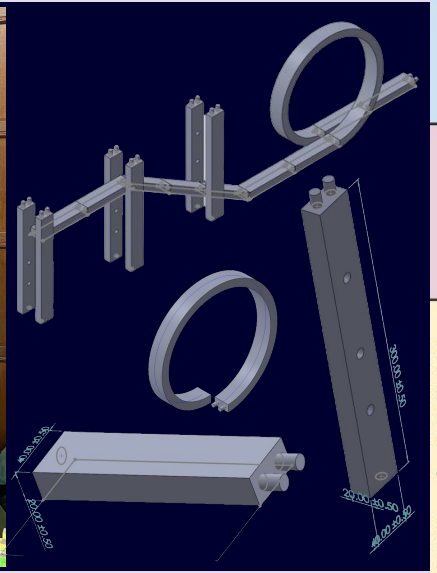
Description

Personally built a custom model rocket to fly at the Upstate Rocketry Research Group (URRG) in New York, and obtained an L1 High Powered Rocketry Certification. Simulated design in OpenRocket and estimated apogee, stability, and flight-time using estimated center of gravity and pressure. Launched as the first successful flight of our group, utilizing a weighted payload ballast to improve stability (previous launches were determined to be less stable than expected). Successfully recovered rocket in perfect condition to refly. Incredibly fun experience both in design and team-bonding! Will fly again in the future to teach others and attempt L2 and L3 certifications.

Montessori Roller Coaster Design Project

Jan - March 2022





<u>Description</u>

As part of a design course, we interacted with a local community: a Montessori school, to develop a requirements model to fit their needs and experience. The task was to create a Montessori toy that taught the kids simple physics concepts as they played with it. We iterated on the requirements and came up with a candidate design: a roller coaster named “Seatbelts Fastened”.

<u>Role</u>

Assigned the “Design Engineer” of the team. Tasked with designing and fabricating the attachment mechanisms to ensure it to be child-safe. Tested it with stakeholders and presented the design at the annual showcase.

Opportunity: Create a physical, gender-neutral, manipulative to deliver STEM concepts of mechanics and motion to grade 1-3 students at Blaisdale Montessori School.

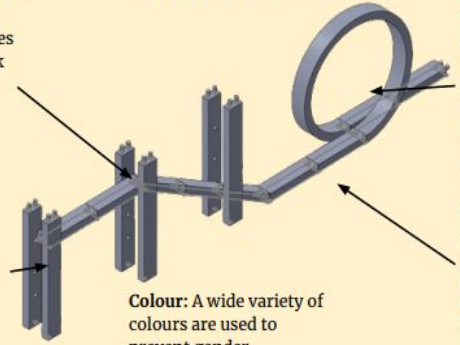
Objectives:

- Present appropriate educational topics
- Ensure ease of assembly and disassembly
- Implement a control of error
- Provide variety of Exploration Opportunities
- Distinguish between components
- Be inclusive and appealing to all genders

Design Features:

Hinges: Demonstrates usage of simple machines and enables for variation in track incline.

Supports: Enables track to be elevated to different heights, demonstrating the impact of height on potential energy and transfer of energy.



Colour: A wide variety of colours are used to prevent gender exclusion.

Loop: Demonstrates circular motion and introduces ideas of centripetal / centrifugal forces.

Tracks: Demonstrates structural stability and implements a control of error, through the orientation of the guide rails.

What do kids and staff think?

- **Kid 1:** “I like that it can be fixed together in different ways, and that you can build different things with it!”
- **Kid 2:** “I learnt that changing the steepness can make the ball go faster
- **Kid 3:** “I feel like I am doing engineering!”
- **Ms Neefjes:** “There is a very good control of error implemented into the design”