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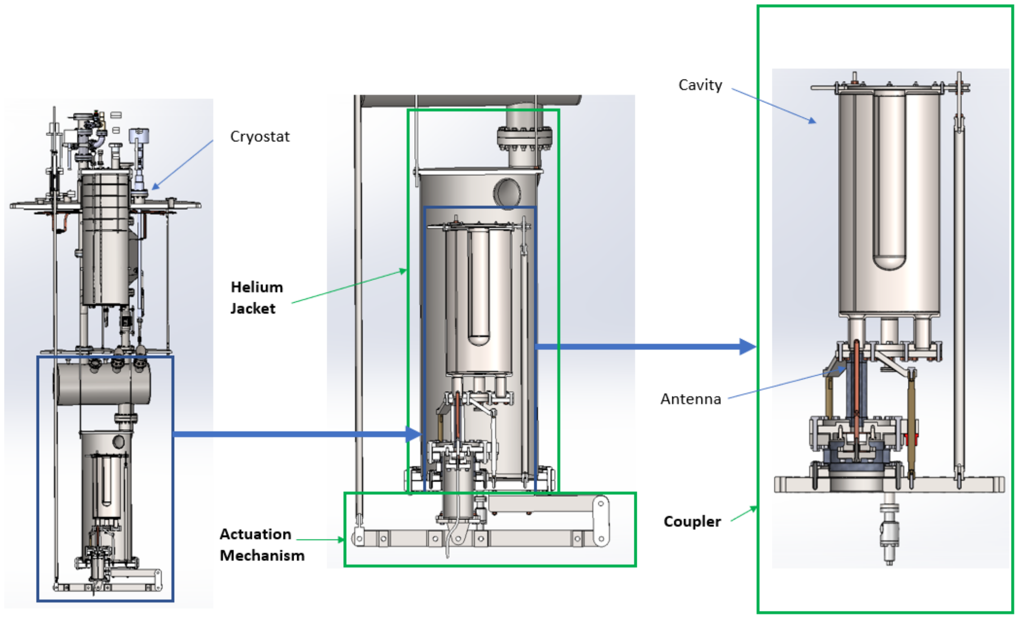
TRIUMF: SRF Cryomodule Team 2022

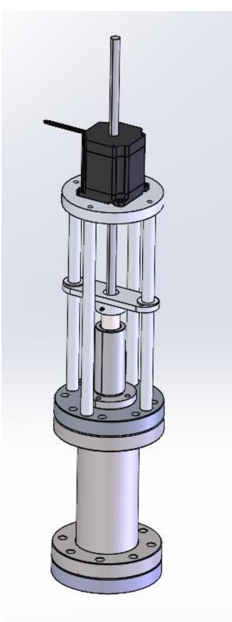
Co-Axial Cavity Test Platform – Conceptual and Detailed Design (Jan – Apr 2022)

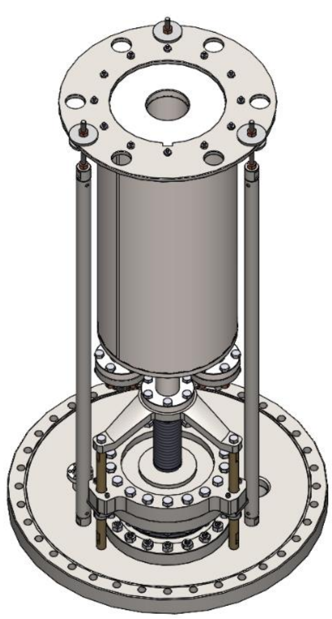
SRF cavities are the heart of most modern particle accelerators. As a member of the SRF Team at TRIUMF, I worked on the conceptual and detailed design of a setup used to qualify the performance of accelerator cavities destined for organizations around the world and to provide a platform to conduct superconductive radiofrequency research. This design would allow cavities to be submerged within a pressure vessel filled with cryogenic liquid helium at 2°K and surrounded by a vacuum.

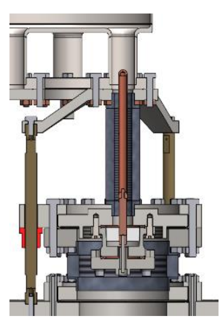
The entire cavity test platform hangs from the lid of a 10 ft tall cryostat. It can be broken up into 3 sections:

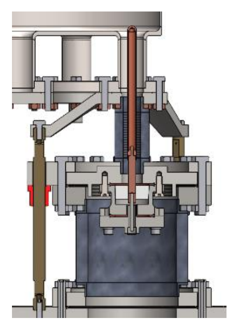
1. *Coupler*
2. *Actuation Mechanism*
3. *Helium*

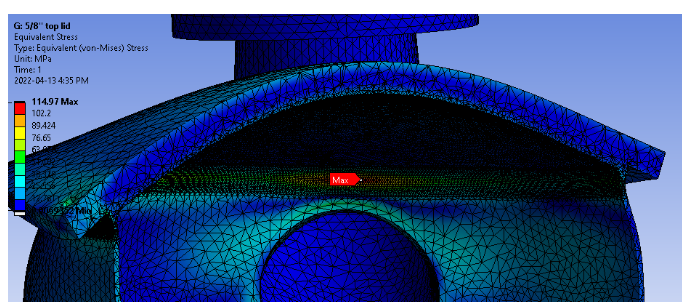












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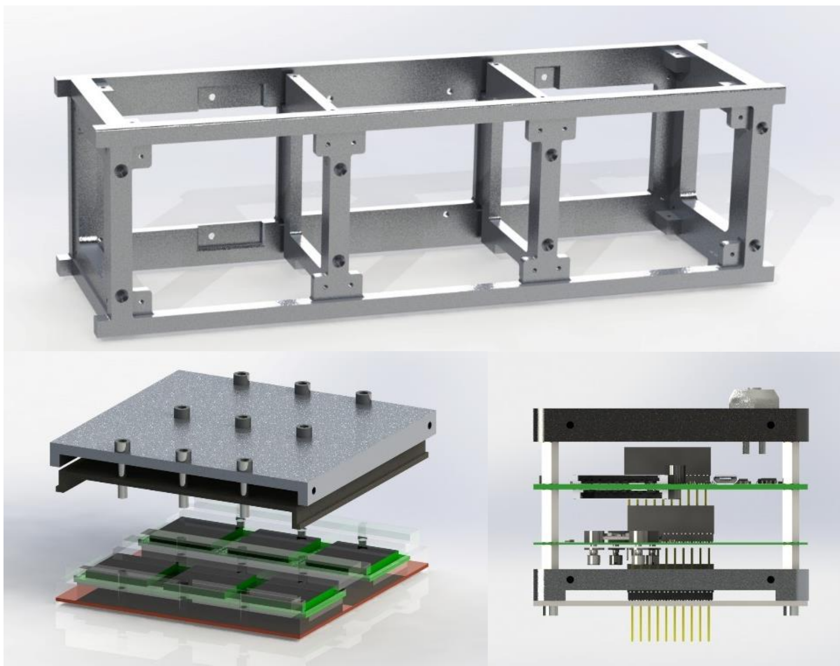
Waterloo Rocketry: Payload 2020-2022

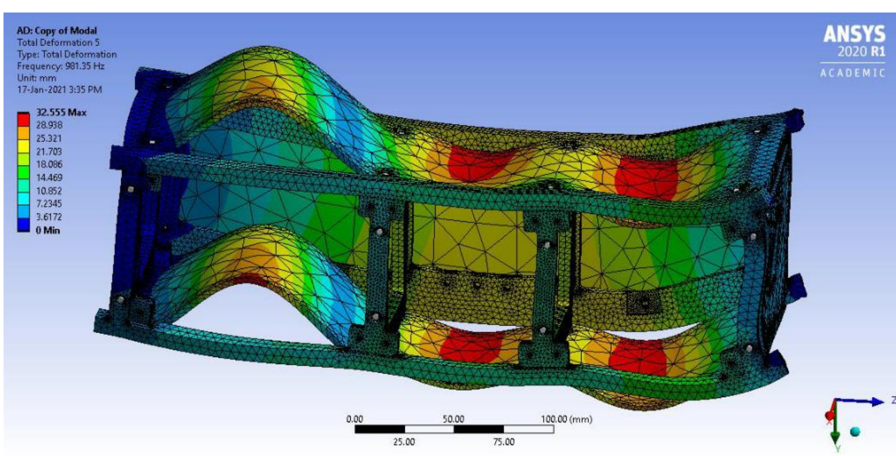
CubeSat Structure & Experiment (Sept 2019 – Jun 2022)

Payloads developed by the team are scientific experiments that take advantage of the high altitudes, extreme launch forces and micro-gravity experienced in our flight up to 30,000 ft. As Payload Lead, I led the design of a 3U CubeSat and radiation sensor suite to test material samples and detect secondary cosmic radiation passing through our rocket. Our payload was eventually selected as one of the Top 10 Payloads in the SDL Payload Challenge and won the prize for Most Professional Design at the Spaceport America Cup 2021/2022 competitions.



CubeSats are a type of standardized nanosatellites. The CubeSat structure on the left was designed to be a modular assembly that minimizes the number of unique parts. Each module slides into the satellite for easy access and operation in the field.

Shown here are renderings of the CubeSat Structure, Detector Module, and Systems Module.



Testing and analysis are important to validate the performance of the payload. Shown above is a screenshot of an ANSYS Modal analysis of the CubeSat and a photo of the anodized/powder coated CubeSat submitted for the 2022 competition.

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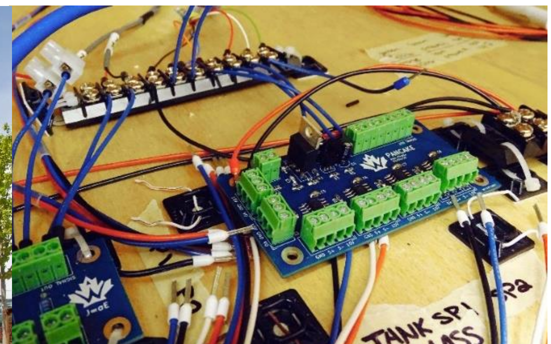
Waterloo Rocketry: Data Acquisition & Test Crew

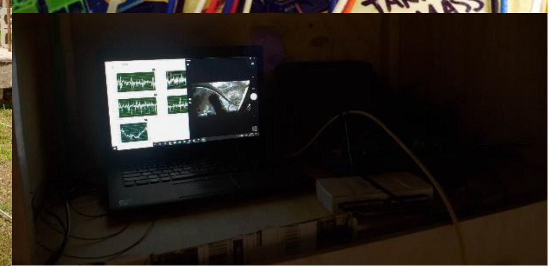
DAQ System, Cold Flow & Hot Fire Engine Tests (Nov 2018 – Mar 2020)

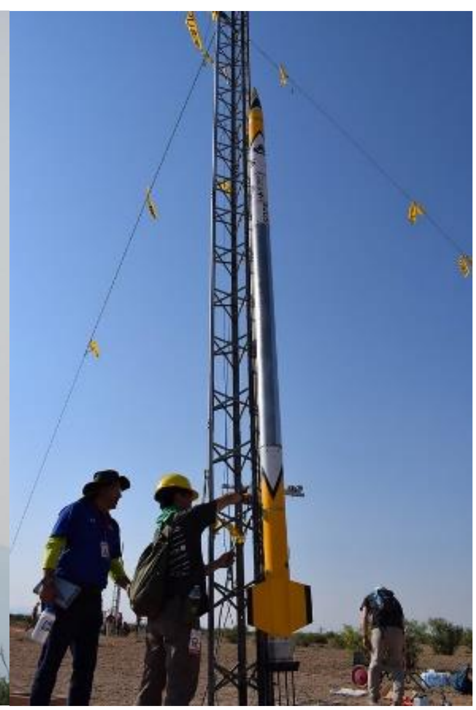
The data acquisition (DAQ) system is responsible for monitoring the performance of our rocket during engine tests and at launch. This is accomplished by a suite of sensors that output signals to an amplification PCB before being sent to a National Instruments DAQ device. This allows us to interpret our data through a program written in LabVIEW.

During cold flow and engine static fires, my job was to set up test infrastructure and operate the DAQ system. Behind the scenes, I worked on noise analyses, sensor calibrations and other improvements to the DAQ system.

Shown here are photos of the DAQ hardware, software, as well as the launch tower and rocket.







Here are some statistics from our most recent hybrid rocket Shark of the Sky (SotS):

- *Height: 5.3 m / 17.4 ft*
- *Diameter: 6 in*
- *Dry Mass: 45 kg*
- *Wet Mass: 72 kg*
- *Total Impulse: 38,000 N·s*
- *Maximum Altitude: 4.7 km / 15,568 ft*

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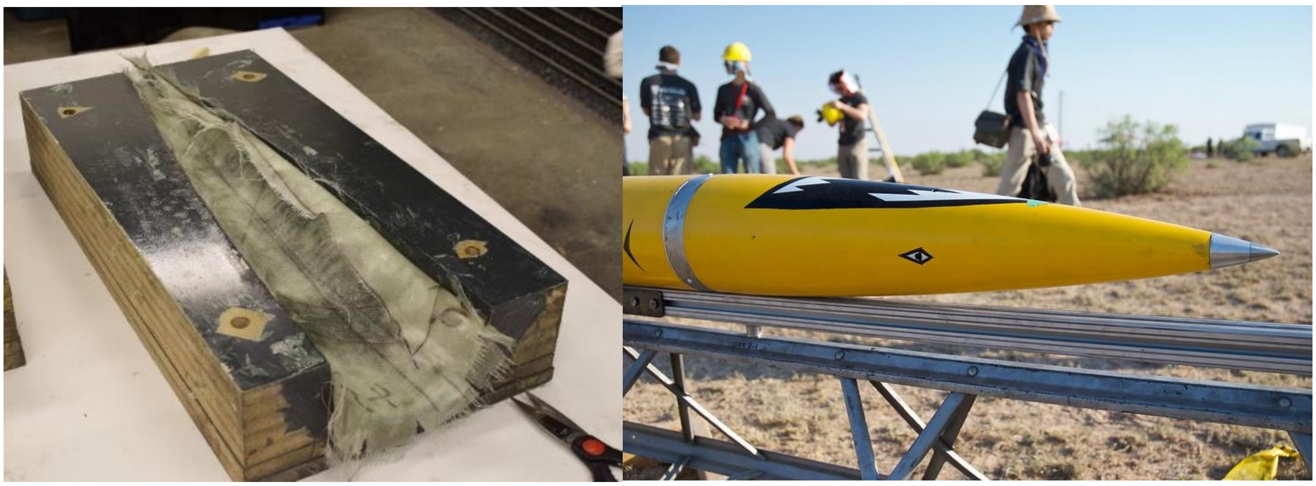
Waterloo Rocketry: Airframe

Composite Layups (May 2019 - Present)

The airframe is the main structure of the rocket. As this is a large contributor to the overall weight of the rocket, great efforts are made to reduce the weight of the airframe. This includes designing and manufacturing composite airframe components made from carbon fibre and fibreglass.



One of the first projects I did with the team was the design of the nosecone. Using a Von Kármán geometry and a 4:1 fineness ratio, the nosecone was optimized for both subsonic and supersonic velocities. This was manufactured using two MDF molds, fibreglass and Aeropoxy.

Another major composite part that was manufactured includes the carbon fibre-epoxy fin can. To produce this part, a vacuum bag layup was required to produce the body tube. Subsequently, three tip-to-tip layups were performed to adhere the carbon fibre fins onto the cylinder.

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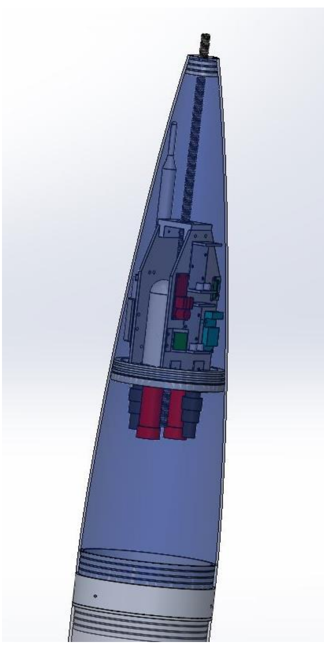
Waterloo Rocketry: Recovery

Avionics Section/Recovery Testing (2019)

The recovery system is integral to safely retrieving the rocket after launch. While the team had a history of past recovery failures, the 2019 system I worked on successfully deployed the drogue parachute, leading to a safe recovery.



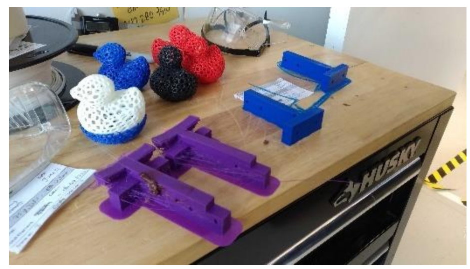
The task was to design the recovery avionics section. This included the electronics sled and bulkhead.

Subsequent recovery tests were conducted to validate system functionality and parachute deployment.

Waterloo Rocketry: Payload 2019

3D-Printed Materials Analysis (2018-2019)

The goal of the 2019 payload was to evaluate the suitability of different 3D printed materials for use in sounding rockets. “T” shaped test samples with notches were placed under steel weights and high launch forces during flight.



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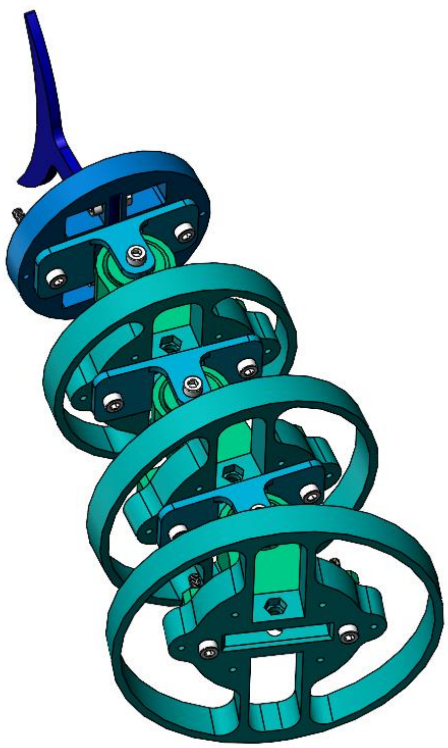
Lamber Labs: Robotic Fish

Mechanical Design (May 2021 – Sept 2021)

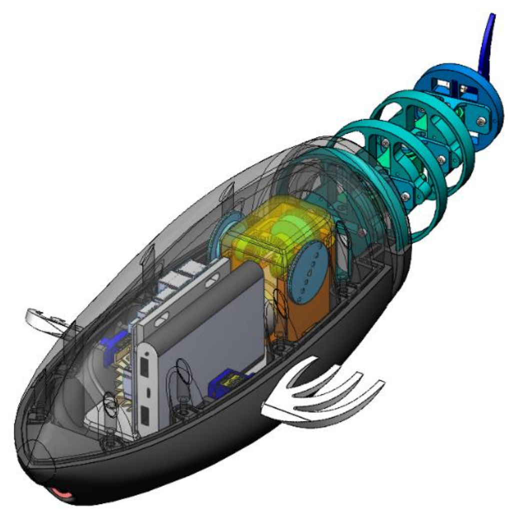
Lamper Labs is a project focused on developing a robotic fish capable of gathering data in shallow ocean environments and blending into its environment for marine biology research. The robotic fish will be wirelessly controlled and will feature a range of sensors and instrumentation to facilitate research purposes.

A major component of the fish is the mechanical design of the propulsion system and enclosure. Mimicking the natural movements of a fish is challenging to replicate and has required multiple design iterations to fine-tune the caudal fin propulsion system.

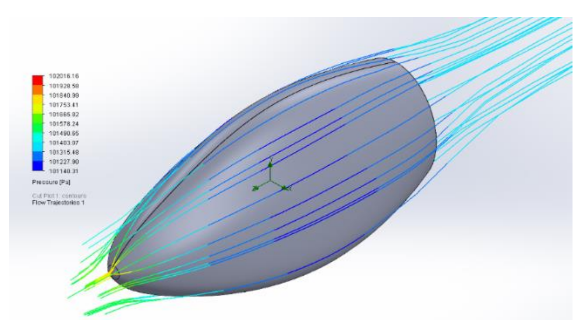


The current propulsion system is a continuous-rotating system where two oppositely rotating turntables (shown in blue below) pull on a set of wires routed through the ribs of the tail seen on the left.

As the turntables rotate opposite of each other, each wire will alternate being in tension while the other remains slack, oscillating the tail – similar to the movements of a tuna for example.



Preliminary work is also being conducted to determine a geometry of the enclosure that will minimize drag and increase stability during swims.



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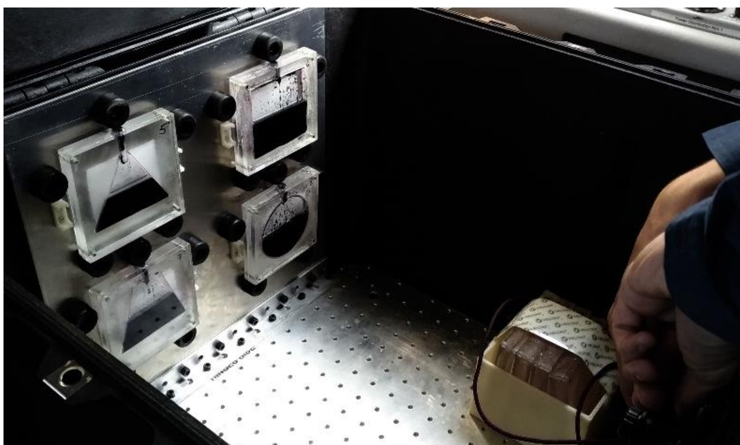
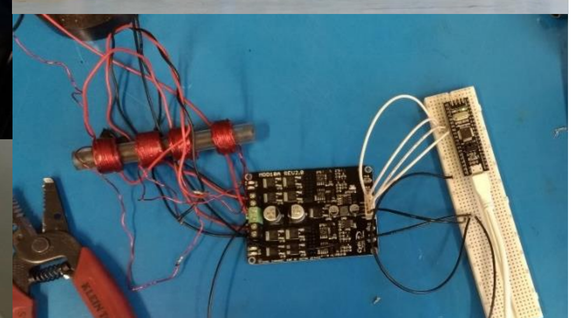
Canadian Reduced Gravity Experiment Design Challenge

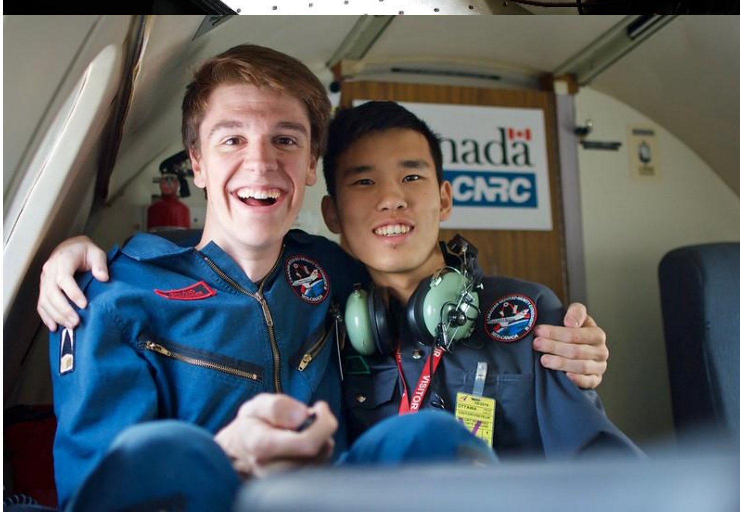
Ferromagnetic Fluids Experiment (2018 - 2019)

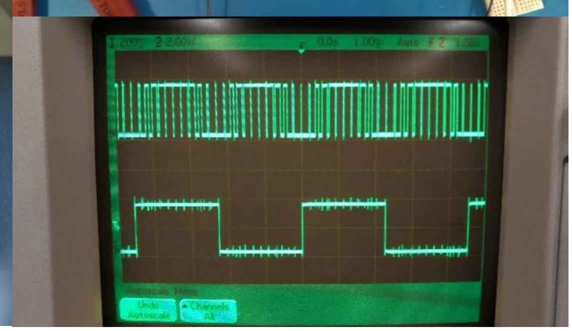
The Canadian Reduced Gravity Experiment Design Challenge (CAN-RGX) is a competition for Canadian post-secondary students to design and test a small scientific experiment on board the National Research Council's Falcon 20 in collaboration with the Canadian Space Agency.

Working with a few other students, we developed an experiment that explored the characteristics of ferromagnetic fluids under the influence of a magnetic field in microgravity. We also designed an experimental solenoid pump controlled by an Arduino to determine whether non-mechanical fluid actuation might be possible in microgravity environments such as in satellite cooling systems or to control dangerously reactive rocket oxidizers.









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Miscellaneous Projects/Hobbies