Portfolio: Mechanical Engineering

Apurva Hanwadikar

I'm a mechanical engineering student at Cornell University, with minors in aerospace engineering, electrical engineering, and physics. My passion lies in space exploration and human spaceflight. I have gained valuable experience as the Integration and Testing Lead for Cornell's CubeSat project and as a member of the Drives Subteam for Cornell Mars Rover. These opportunities have deepened my understanding of space systems and further fueled my curiosity to explore this field. Additionally, I am committed to fostering a more inclusive aerospace industry, which I've contributed to as the Mentorship Coordinator for Women in Aerospace and Aeronautics at Cornell.

contact:
apurvahan@gmail.com
https://www.linkedin.com/in/apurva-hanwadikar/

INTEGRATION AND TESTING LEAD, ALPHA CUBESAT

As part of Cornell's Alpha CubeSat project, I led the design, testing, and optimization of the CubeSat's dipole antennas to ensure reliable communication and deployment in space.

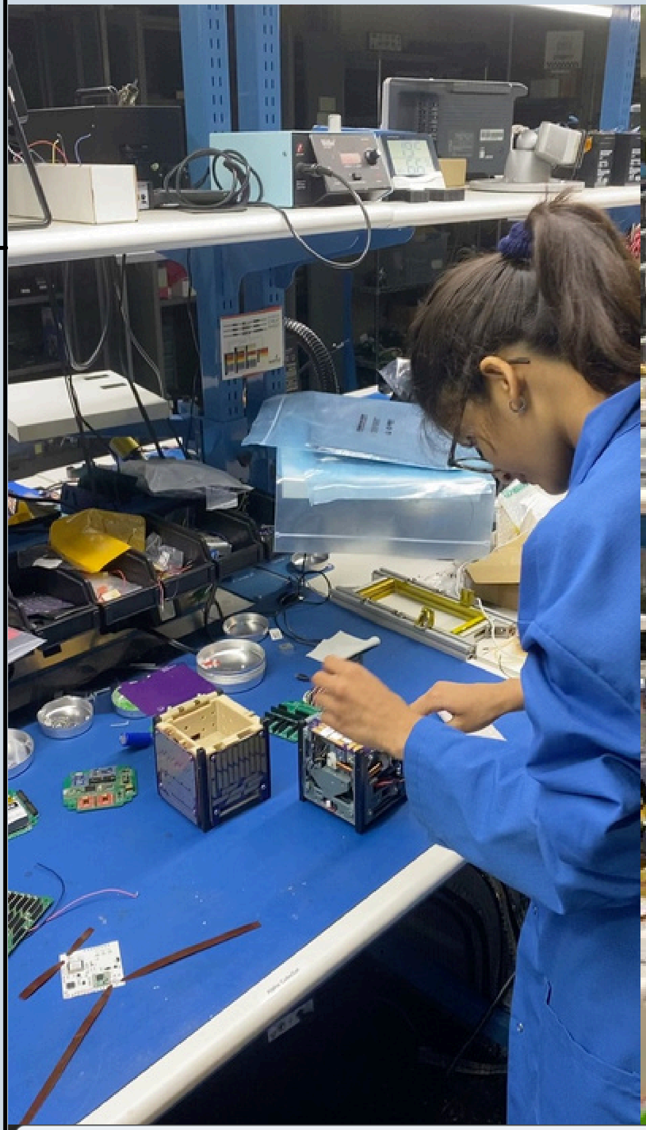
Key Contributions:

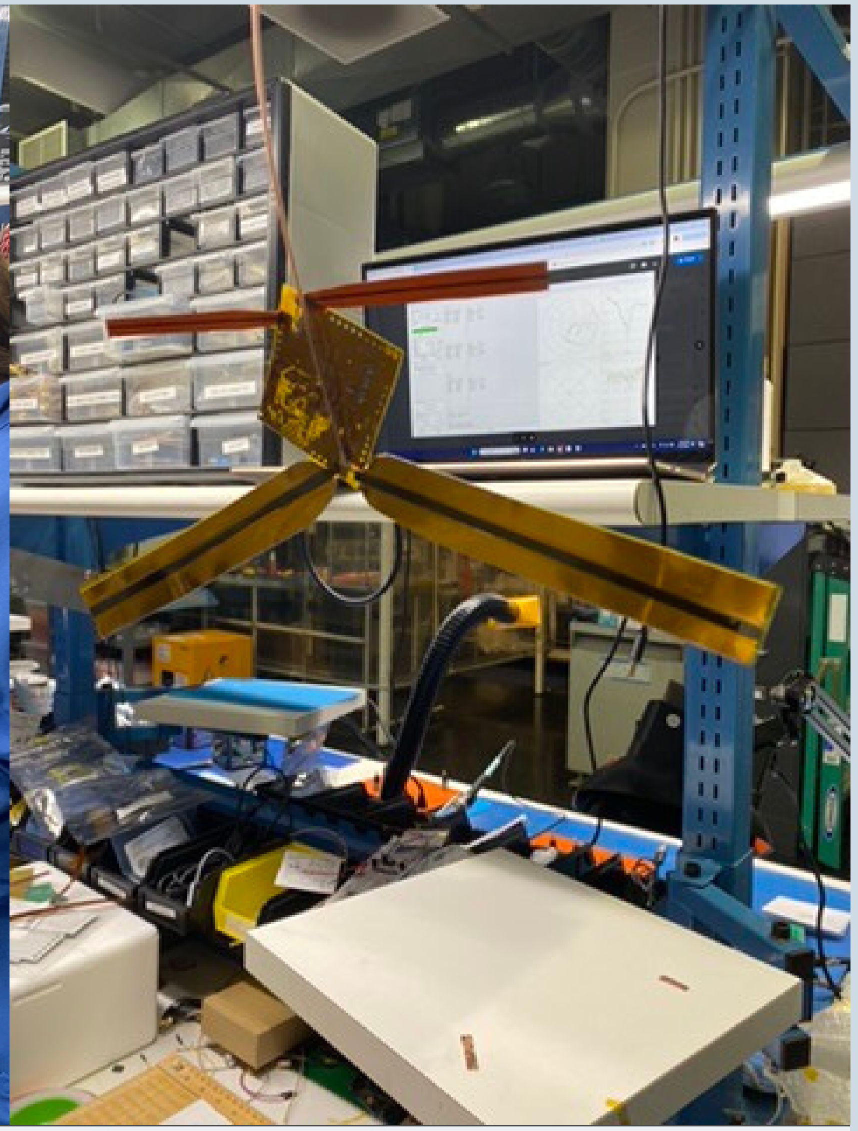
- Design Optimization: Finalized antenna designs, performing frequency analysis and impedance matching for optimal signal performance.
- Interference Mitigation: Addressed signal disruption issues by configuring hinged and unstiffened antennas diagonally to reduce interference.
- Material Integration: Tuned antenna lengths to account for nitinol's conductive properties in deployment mechanisms.
- Testing and Validation: Conducted high-altitude balloon tests to validate performance, successfully receiving GPS data and confirming communication capabilities.

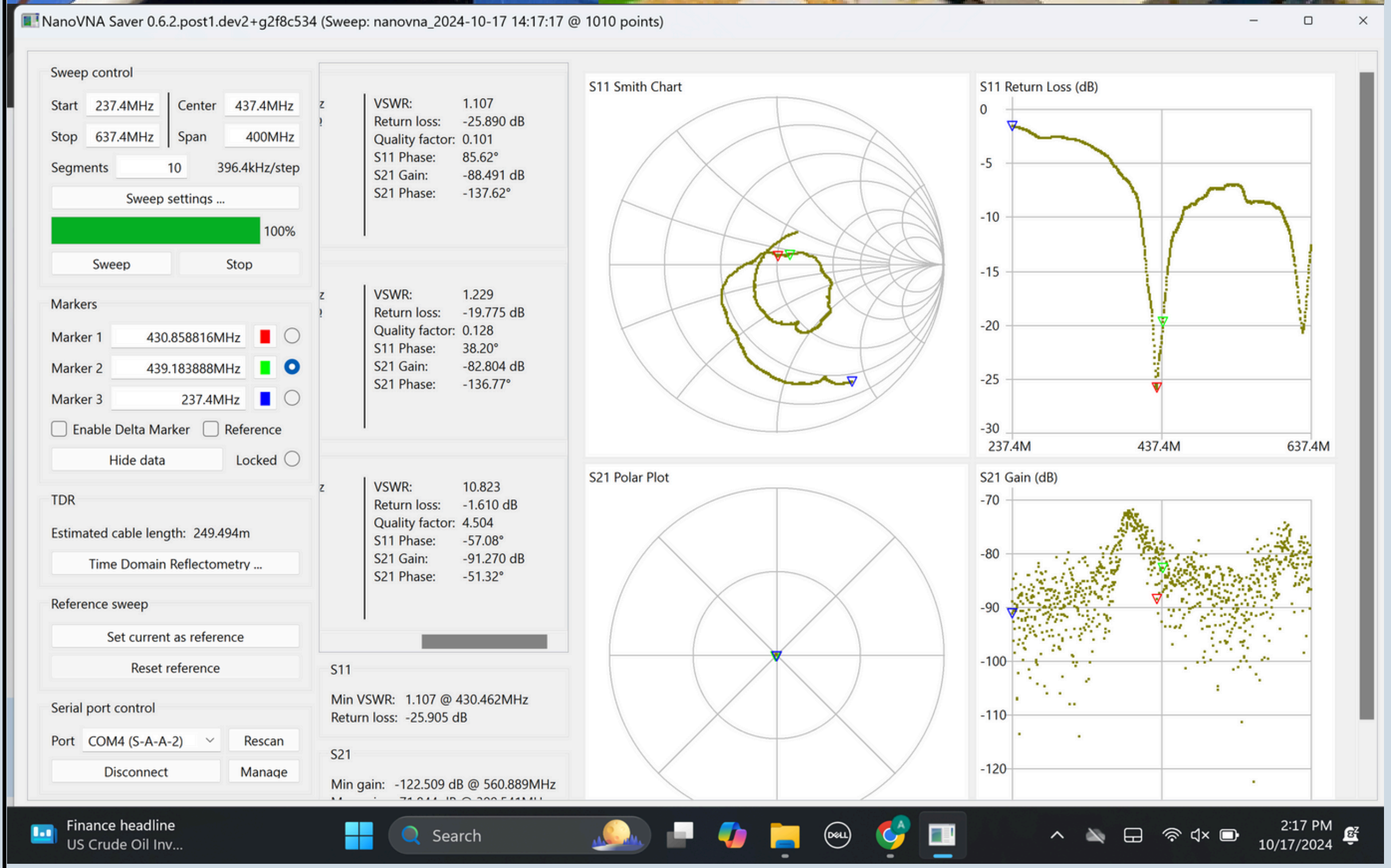
Results:

- Validated antenna functionality under near-space conditions, informing final deployment configurations and enhancing mission reliability.

This project provided hands-on experience in RF system design, testing, and troubleshooting for space applications.





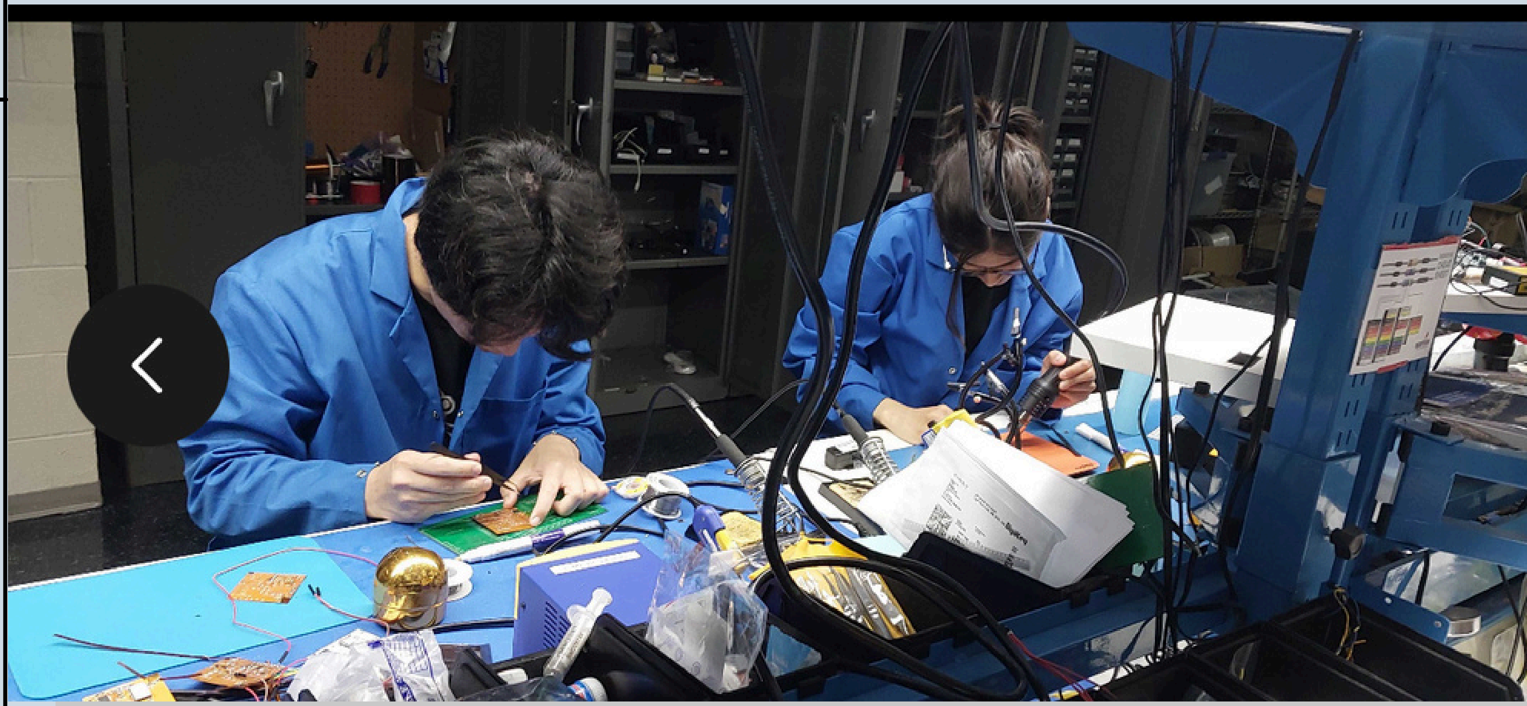


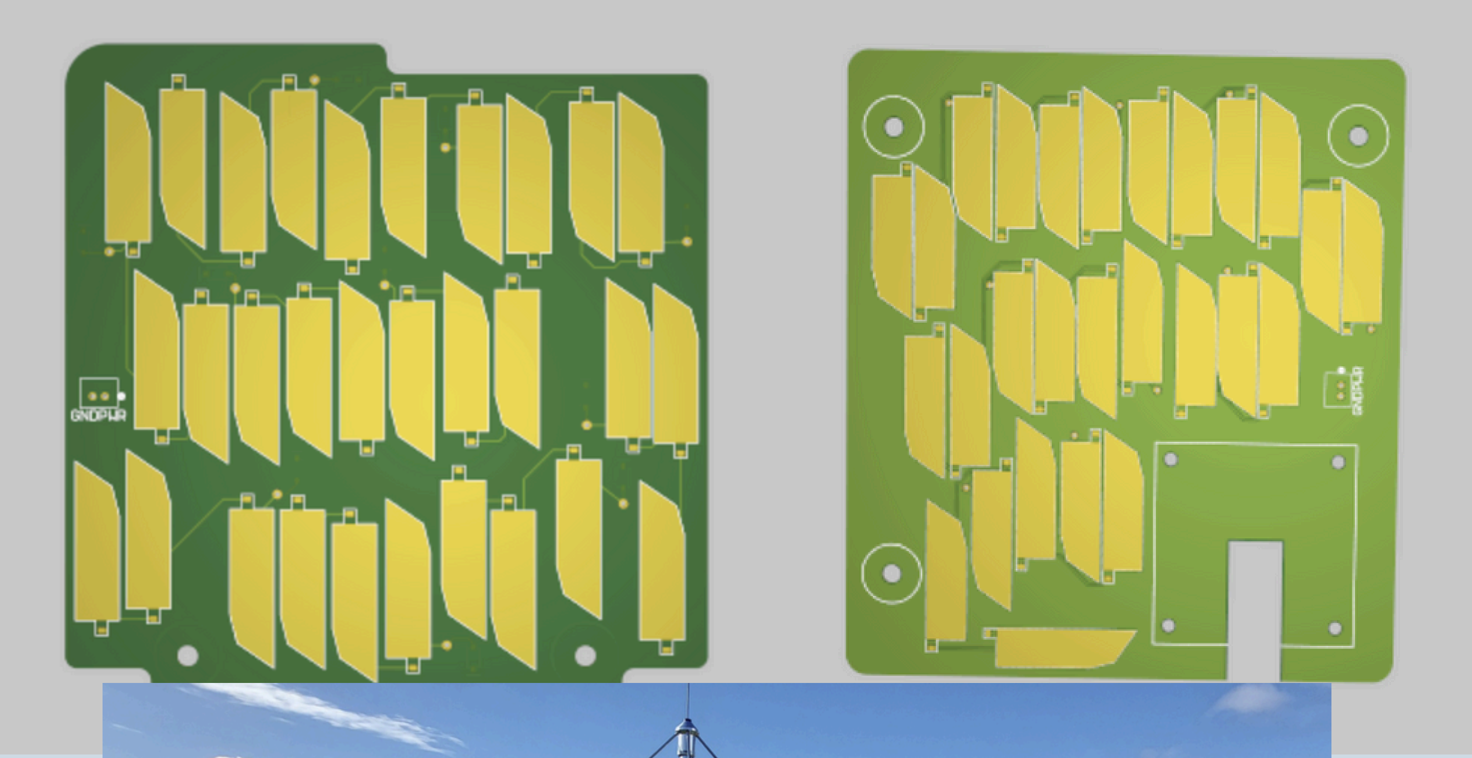
ELECTRICAL WORK FOR ALPHA CUBESAT

I contributed to the electrical development of Alpha CubeSat and related missions through design optimization, soldering, and testing.
Key Contributions:

- PCB Debugging: Debugged and repaired PCB designs for the high-altitude balloon CubeSat, ensuring operational reliability.
- Impedance Matching: Performed circuit-level impedance matching using capacitors, inductors, and resistors for the DeSCENT mission.
- Microsoldering Expertise: Soldered components onto PCBs and ChipSats with precision, enhancing system functionality.
- Solar Panel Assembly: Assembled and soldered photovoltaic cells for Alpha CubeSat solar panels, followed by rigorous solar testing to confirm their performance.

This work strengthened my skills in circuit design, troubleshooting, and microsoldering, while contributing to the successful assembly and testing of space systems.





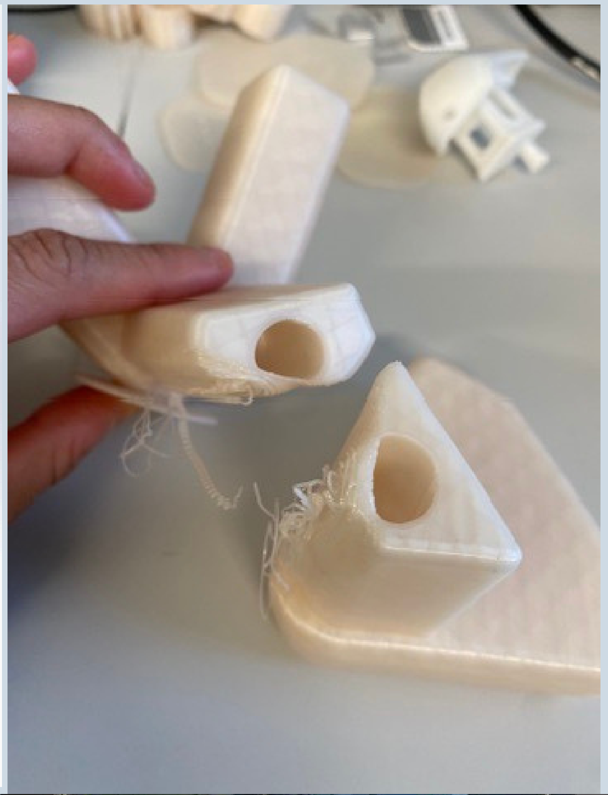
MECHANICAL WORK, ALPHA CUBESAT

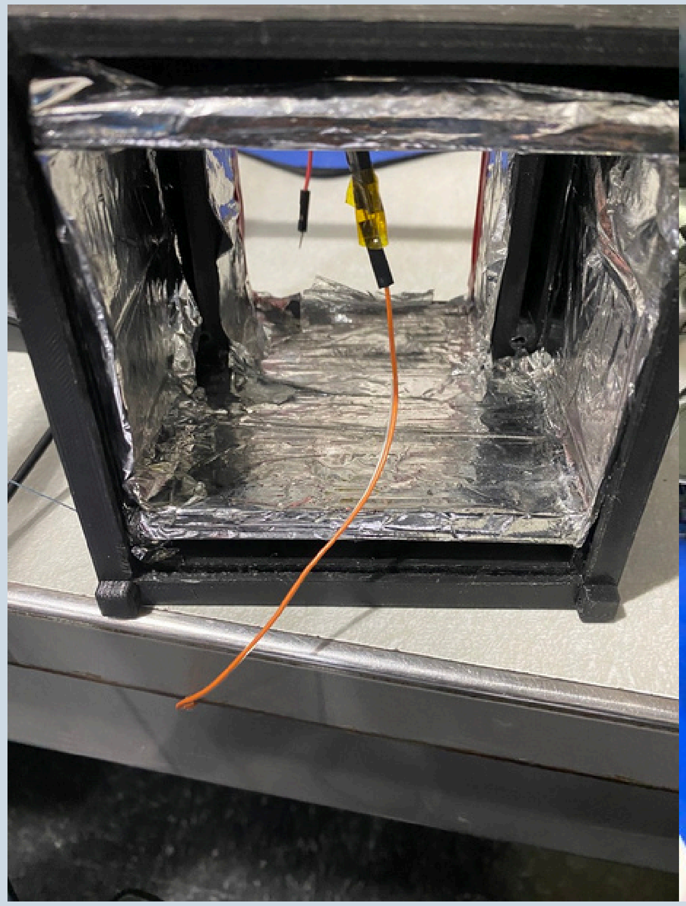
I contributed to the mechanical design, assembly, and testing of critical systems for Alpha CubeSat, ensuring reliable deployment and stability during flight.

Key Contributions:

- Payload Frame Design: Designed and built the frame suspending the CubeSat to the balloon using clear PVC pipes, CAD modeling in SOLIDWORKS, and 3D-printed mounts and connectors.
- Camera Stabilization: Developed a method to stabilize onboard cameras during the shaky launch phase for clearer data collection.
- Tethering System Development: Designed and modeled the tethering system to secure the lightsail payload, performing center-of-gravity calculations to optimize suspension lengths and balance.
- Light Sail Optimization: Created a reliable assembly method to enhance deployment performance.
- Clean Room Assembly: Participated in final flight assembly and critical hardware integration steps in a clean room environment.

This work deepened my expertise in CAD modeling, structural design, and precision assembly, preparing the CubeSat for high-altitude balloon testing and deployment.





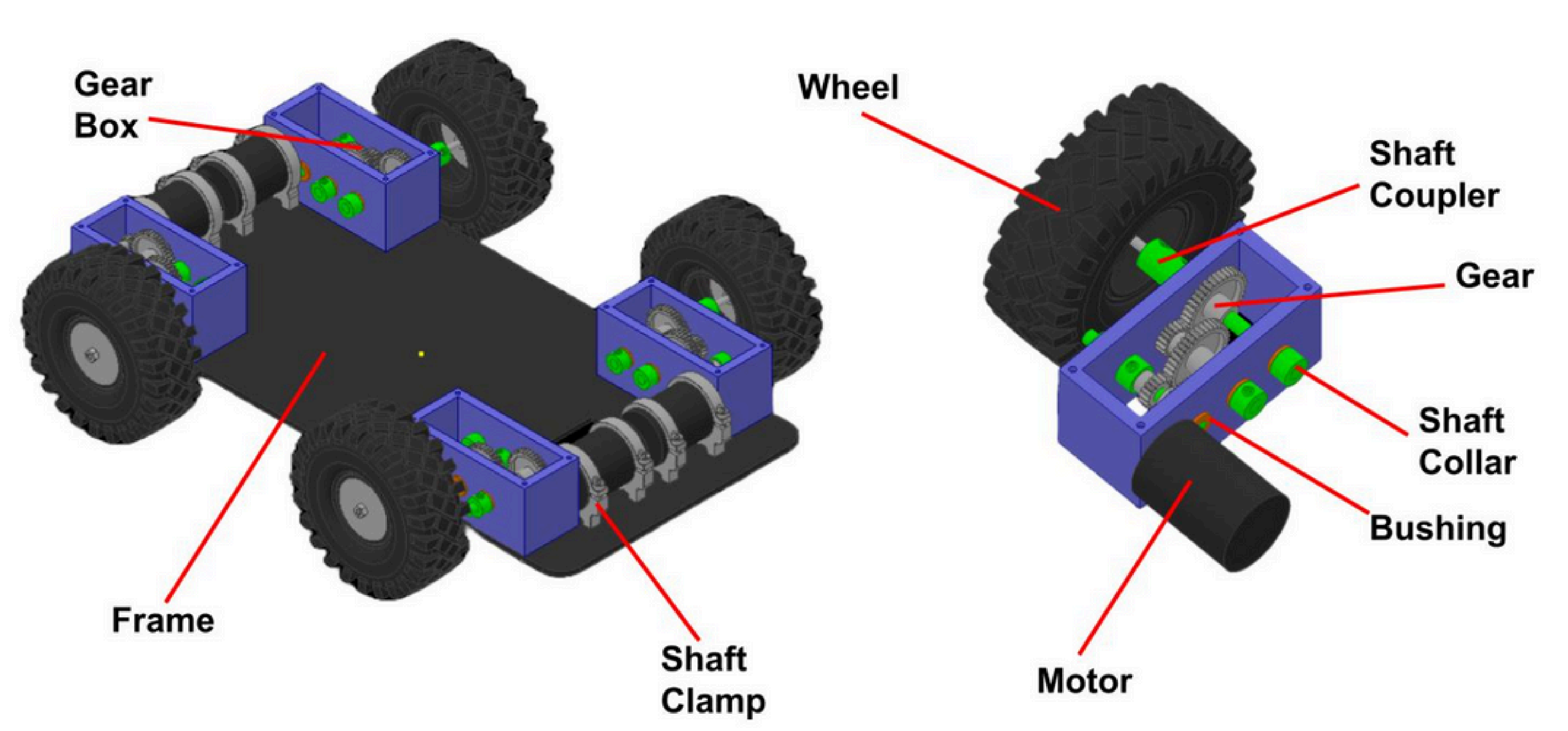
CORNELL MARS ROVER, MECHANICAL

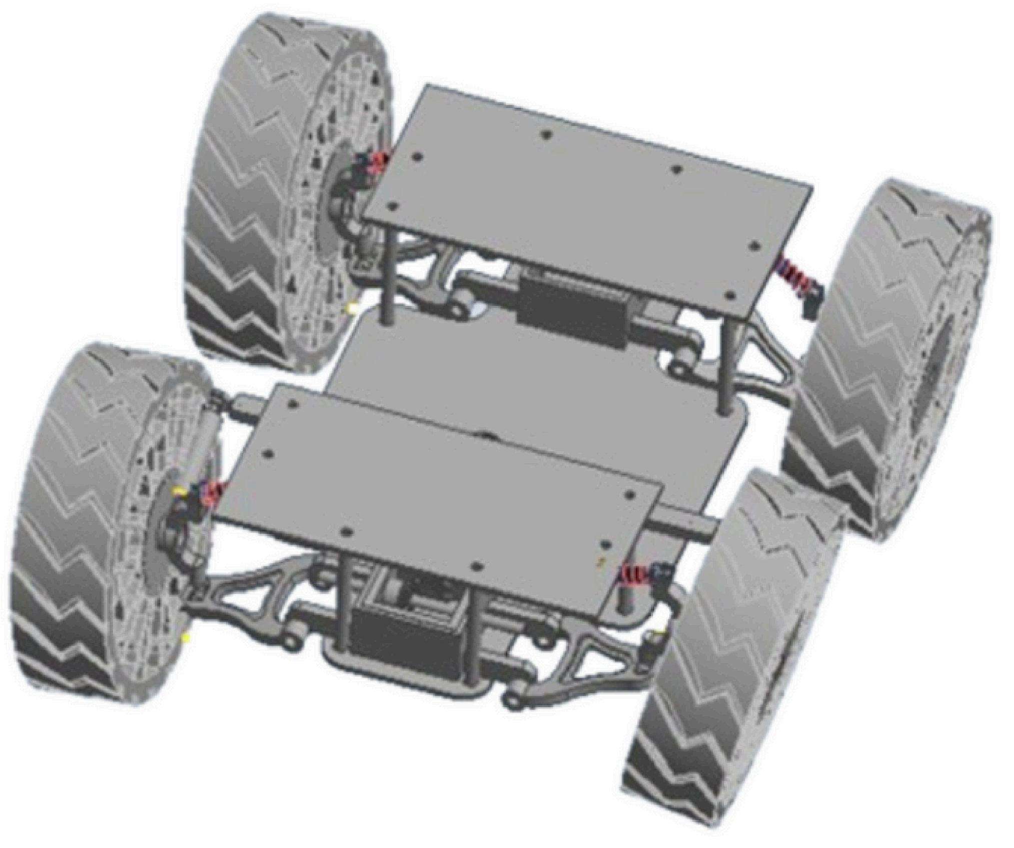
I contributed to the design and assembly of a deployable mini-rover intended to function as a radio repeater set for the Cornell Mars Rover team.

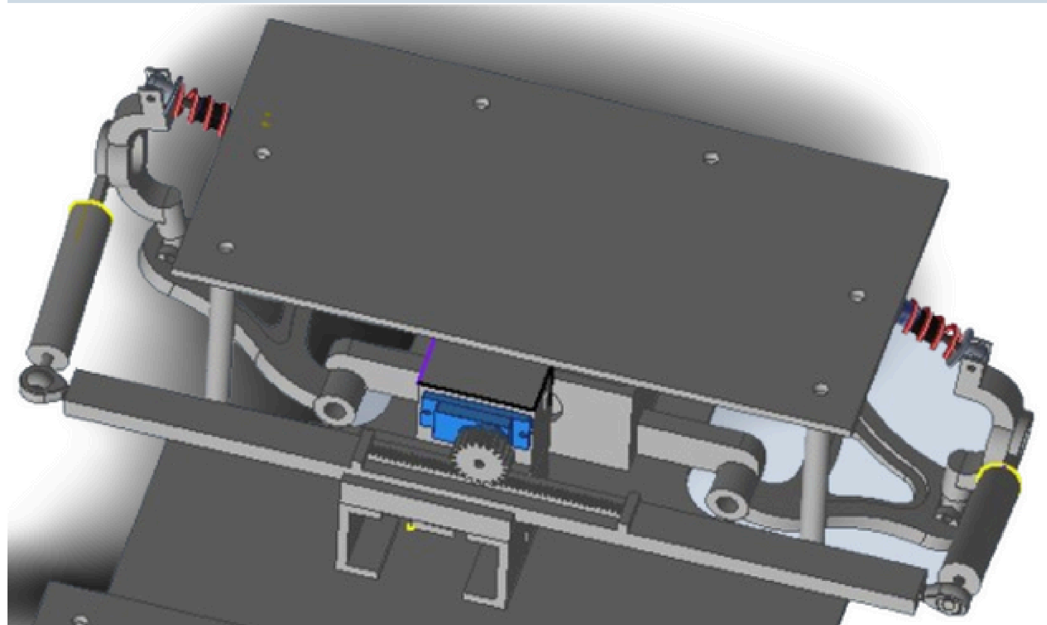
Key Contributions:

- Ackermann Steering Design: Modeled and implemented Ackermann steering in Autodesk Inventor to improve maneuverability.
- Direct Drive Pivot: Designed a differential drive and suspension system but pivoted to a direct drive system due to time constraints, optimizing for efficiency and manufacturability.
- Gearbox Development: Designed and assembled a 1:30 gear reduction gearbox using three parallel gears to power each wheel, ensuring reliable performance.
- System Assembly: Successfully built and integrated all gearboxes and completed the full system assembly.

This project enhanced my skills in CAD modeling, mechanical design, and precision assembly, while also teaching me to adapt designs to meet project timelines and constraints.







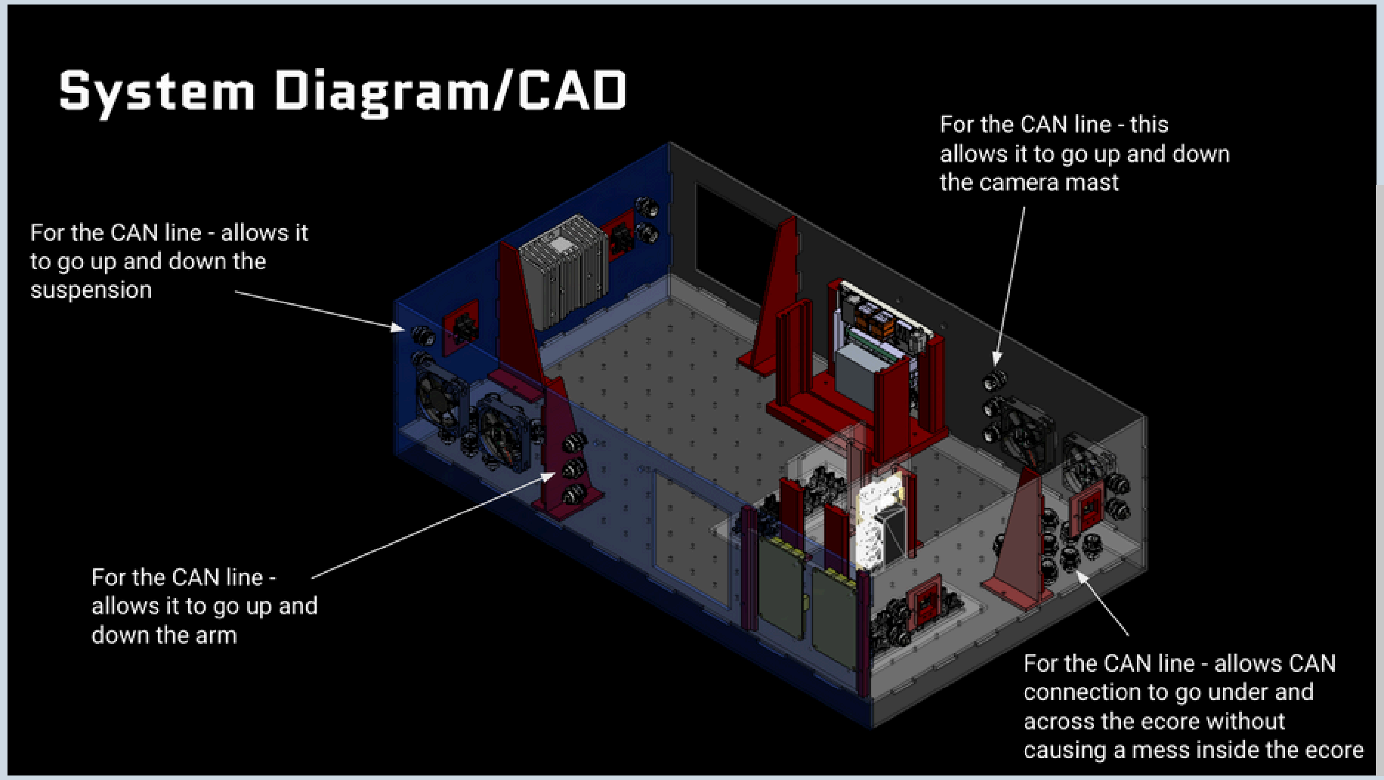
CORNELL MARS ROVER, ELECTRICAL

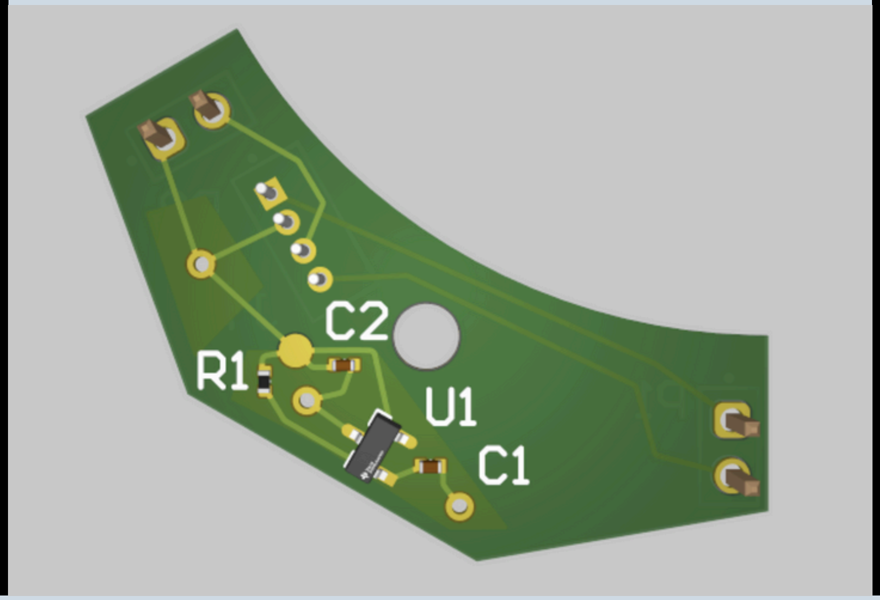
I contributed to the Cornell Mars Rover project by designing and assembling the avionics bay and developing a PCB for motor position sensing, ensuring efficient and modular system design.

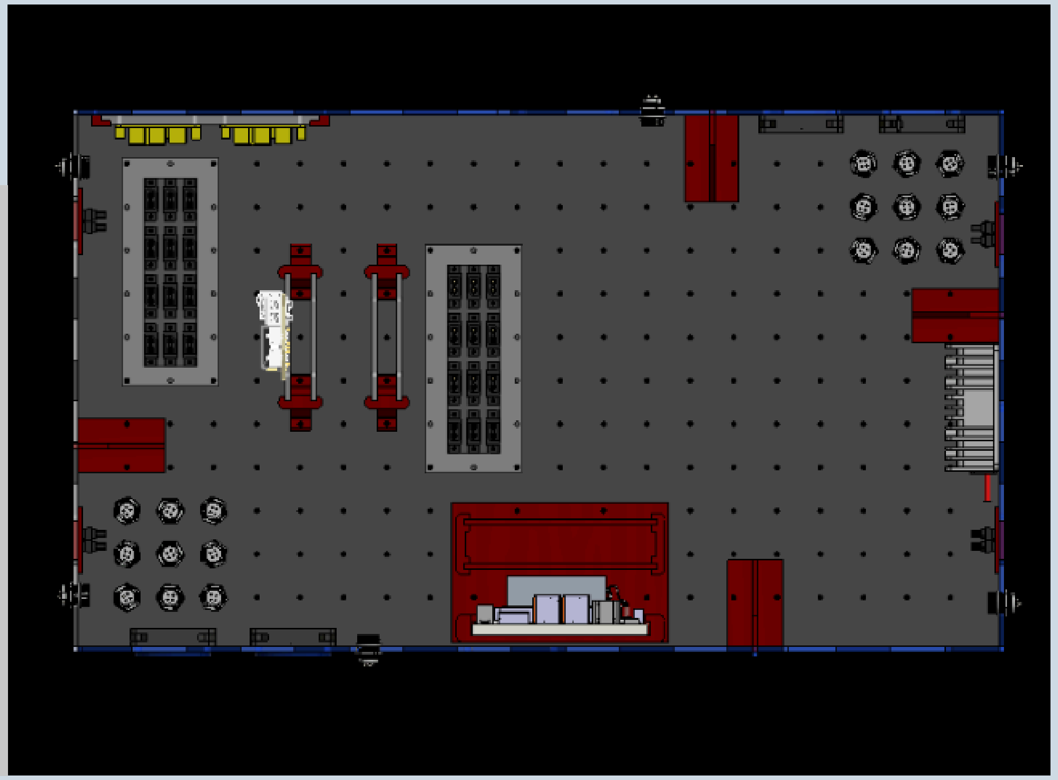
Key Contributions:

- Avionics Bay Design:
  - Developed a plug-and-play system for organizing circuit boards to minimize wire lengths and improve accessibility.
  - Designed mounting systems for all boards and a sliding system for frequently modified components.
  - Created a pegboard design for the bay frame in Autodesk Inventor, enabling modular assembly.
  - Assembled a prototype, with the final design currently in progress.
- Hall Effect Sensor PCB:
  - Designed a PCB in Altium for a Hall-effect sensor to zero motor positions for the rover's suspension system.
  - Planned to code motor control and conduct testing in Python to ensure accurate performance.

This project enhanced my skills in CAD modeling, PCB design, and system integration while reinforcing the importance of modularity and organization in complex electrical systems.







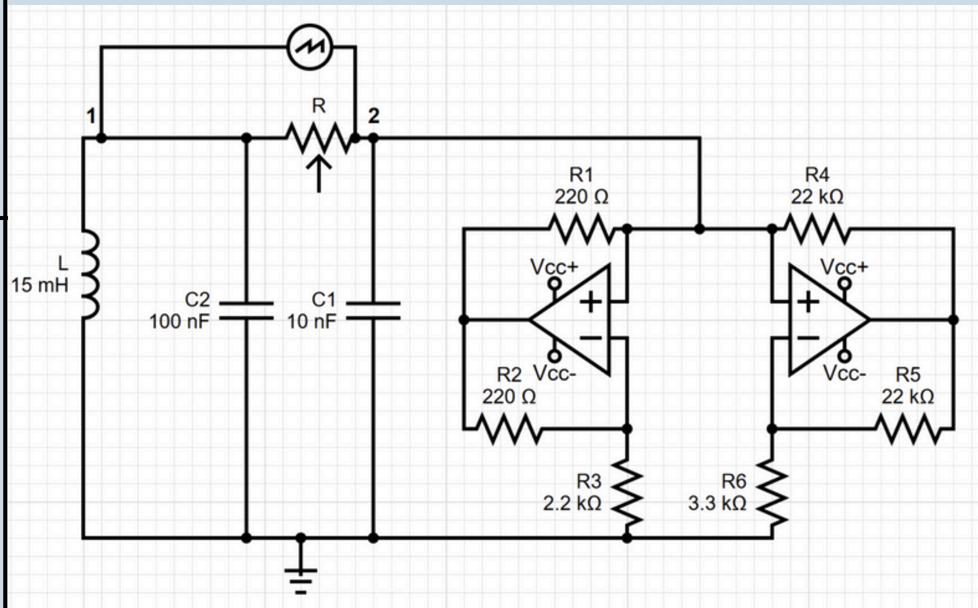
EXPERIMENTAL PHYSICS POSTER SESSION

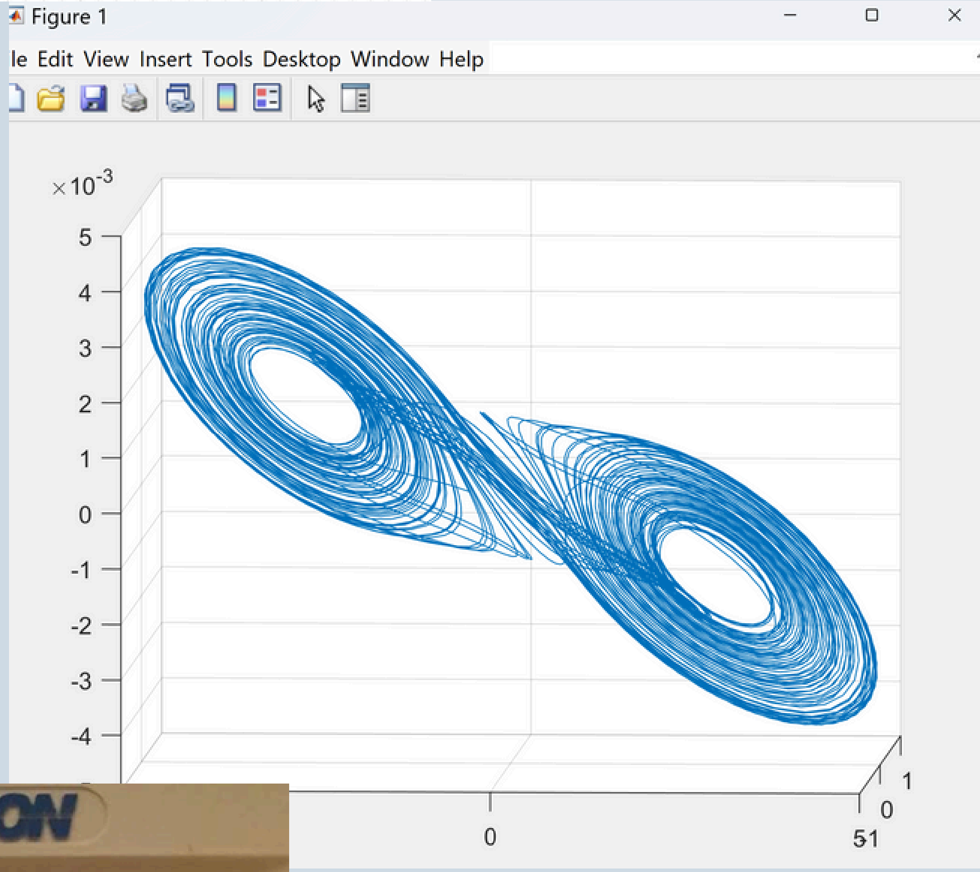
I conducted a hands-on experimental physics project to study chaos in a Chua circuit, focusing on the relationship between resistance and chaos, as quantified by Lyapunov exponents.

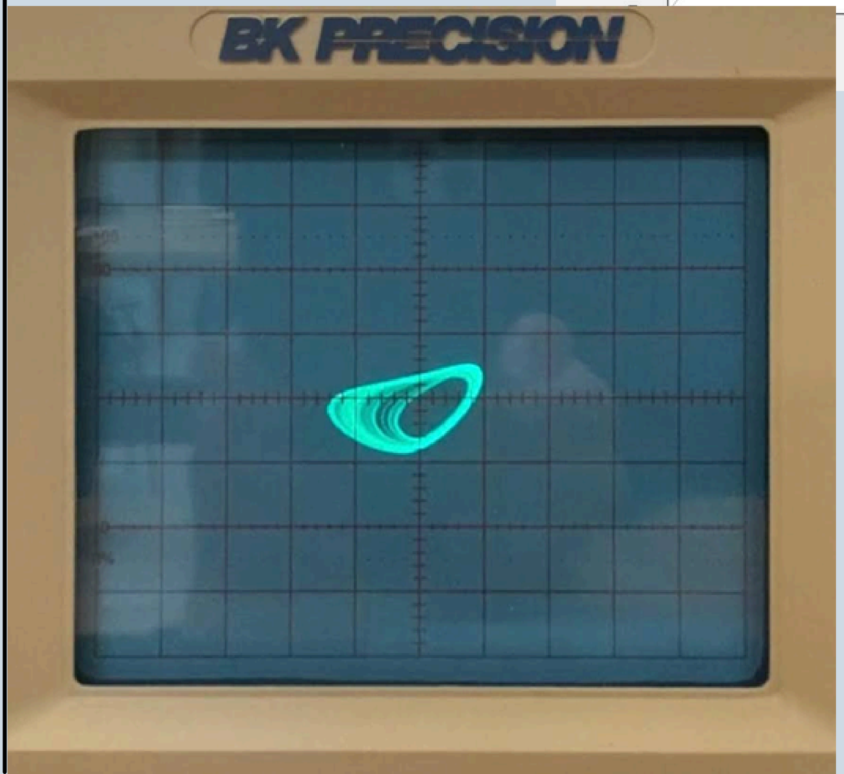
Key Contributions:

- Circuit Setup and Data Collection: Built an RLC circuit with a potentiometer to vary resistance and used oscilloscopes to capture voltage time series data for chaotic and non-chaotic regimes.
- Quantifying Chaos: Calculated Lyapunov exponents by analyzing the divergence of nearby trajectories in voltage time series, using MATLAB and Python to process data and create visualizations.
- Visualization: Reconstructed strange attractors from oscilloscope data to confirm chaotic behavior in the circuit, identifying single-scroll attractors for specific resistance values.
- Error Analysis: Identified sources of uncertainty in resistance measurements and time-series data, including multimeter limitations and data coarseness, and proposed improvements for future experiments.
- Theoretical Connections: Explored differential equations describing the Chua circuit and their parallels with established chaotic systems like the Lorenz map.

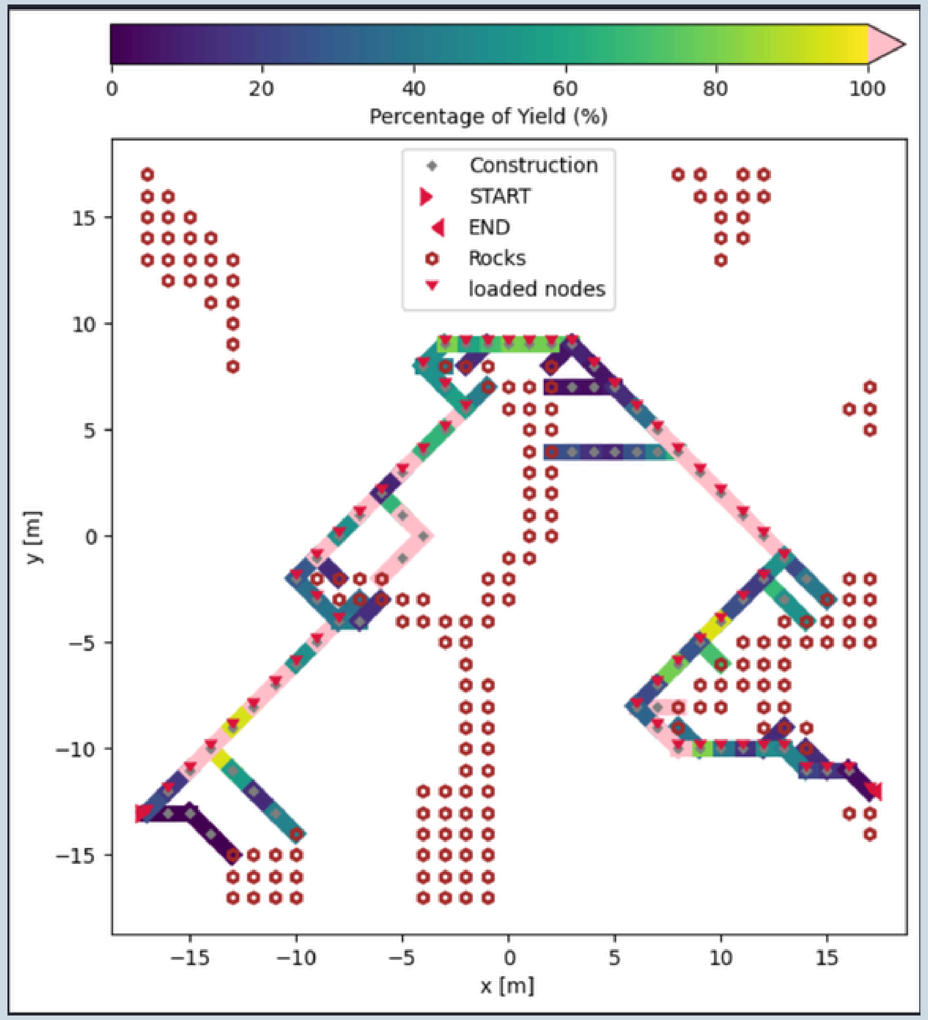
This project sharpened my skills in experimental design, programming, and analyzing nonlinear systems, while deepening my understanding of chaos theory and its practical applications.



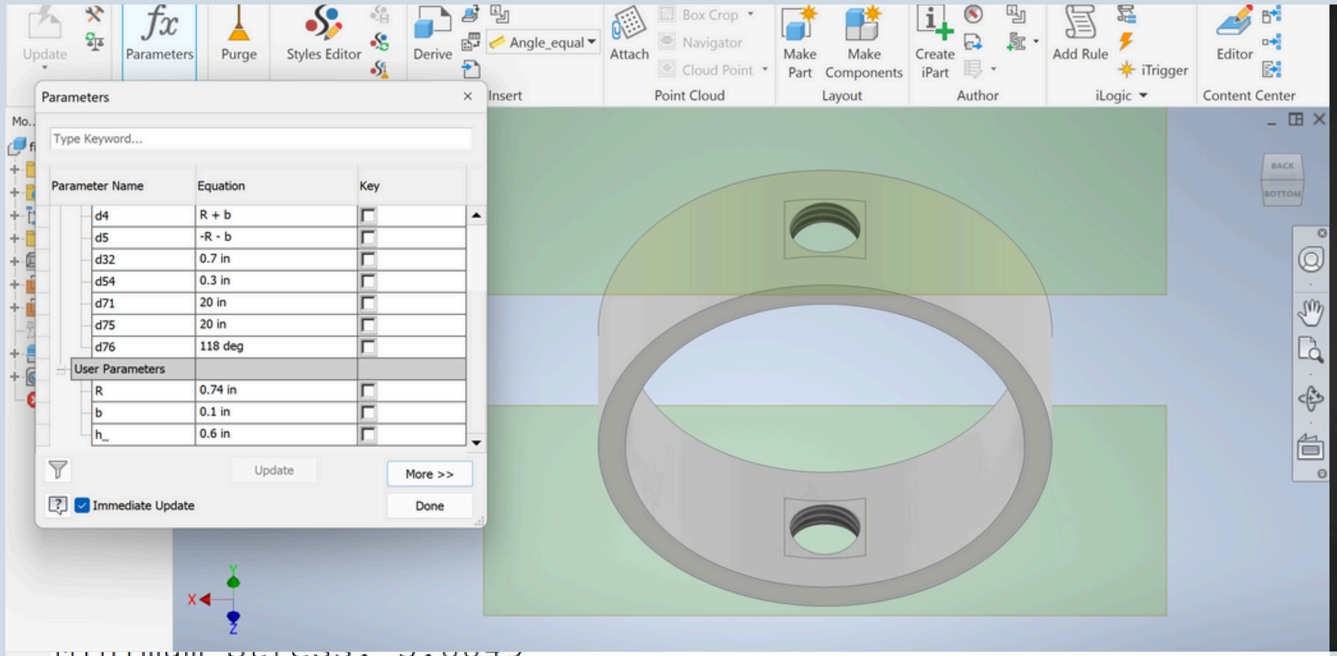


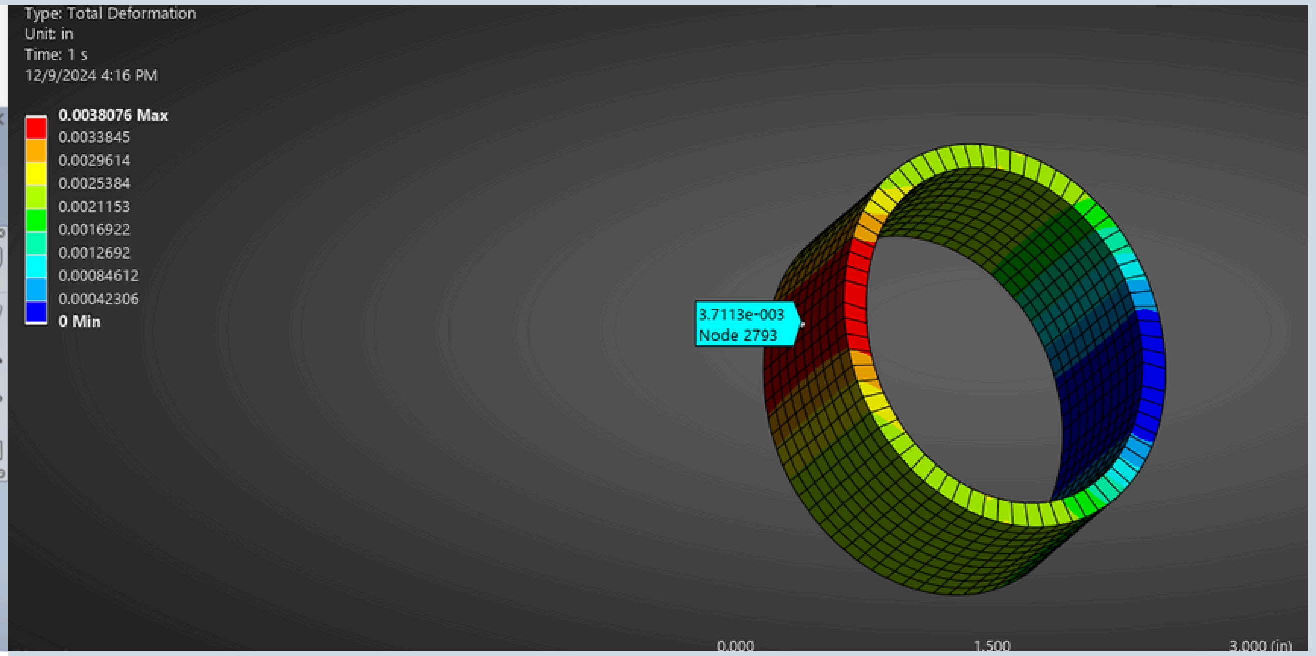


ASSORTED PROJECTS IN COLLEGE



Ansys Codefest: Simulated a complicated bridge structure using nodes (similar to the nodes used for FEA analysis in ANSYS) and used Python code to determine the best possible route, design, and materials.






```
Radius: 0.7400
h: 0.1000
b: 0.6000
>> load_cell_testing
deflection at load point: 0.048084
safety factor for strength: 2.8695
safety factor for fracture: 6.065
safety factor on fatigue: 1.5028
maximum normal stress anywhere: 47047.047
outer strain at gauge: 2760.5116
inner strain at gauge: -3124.4126
stress at outer gauges: 25286.2863
stress at inner gauges: -28619.6196
the voltage ratio is: 5.8849
Our material is: Titanium, beta alloy Ti-12Mo-6Zr-2Fe
with a Youngs modulus (in psi) of: 9160000
a tensile strength (in psi) of: 135000
```

For my Mechanics of Materials final project, I optimized a baseline load cell design to maximize voltage output while maintaining safety requirements. I wrote a MATLAB script to iterate through design choices, ensuring the best voltage output passed all safety factor tests. The final design was modeled in Autodesk Inventor and analyzed in ANSYS to verify stress distribution and ensure there were no stress concentrations, meeting the required safety standards.

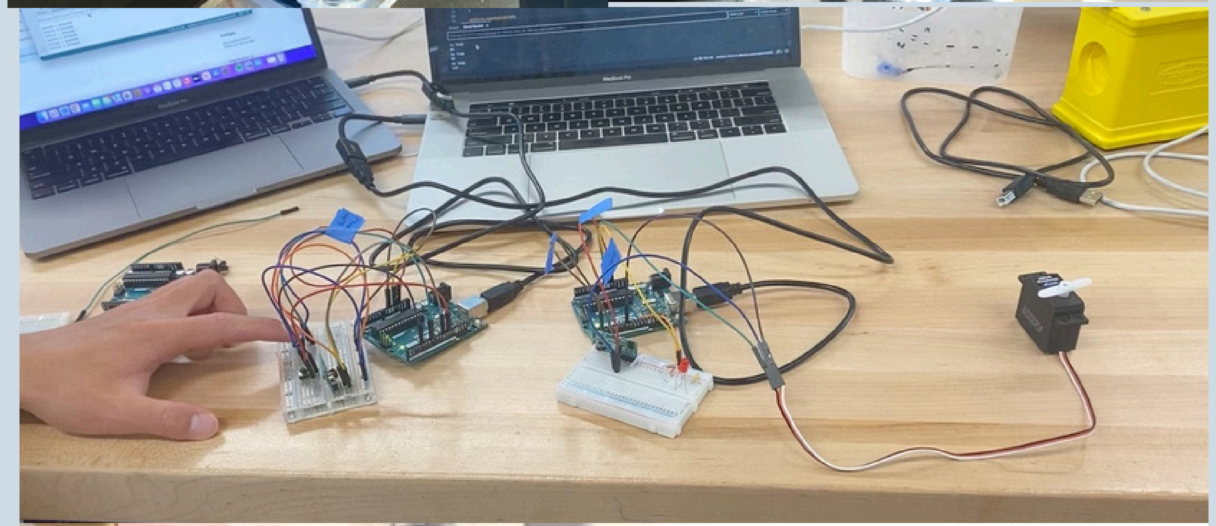
CAPSTONE PROJECT

My high school capstone project aimed to design and build an automatic door-closing mechanism to enhance security during lockdown scenarios, such as school shootings. The system used a lever arm extension for automatic opening and closing, paired with an electromagnet for automated locking.

Key Contributions:

- Mechanical Design: Led the CAD modeling of the lever arm mechanism and designed key components using 3D printing and laser cutting techniques.
- Prototype Construction: Built a functional prototype door using workshop tools to simulate real-world conditions.
- Circuitry and Programming: Collaborated on breadboarding the electromagnetic circuit and wrote Arduino code to control the system.
- Presentation: Demonstrated the working prototype to a U.S. House of Representatives representative, showcasing its potential for improving school safety.

This project honed my skills in mechanical design, prototyping, and integrating hardware with software to address real-world challenges.



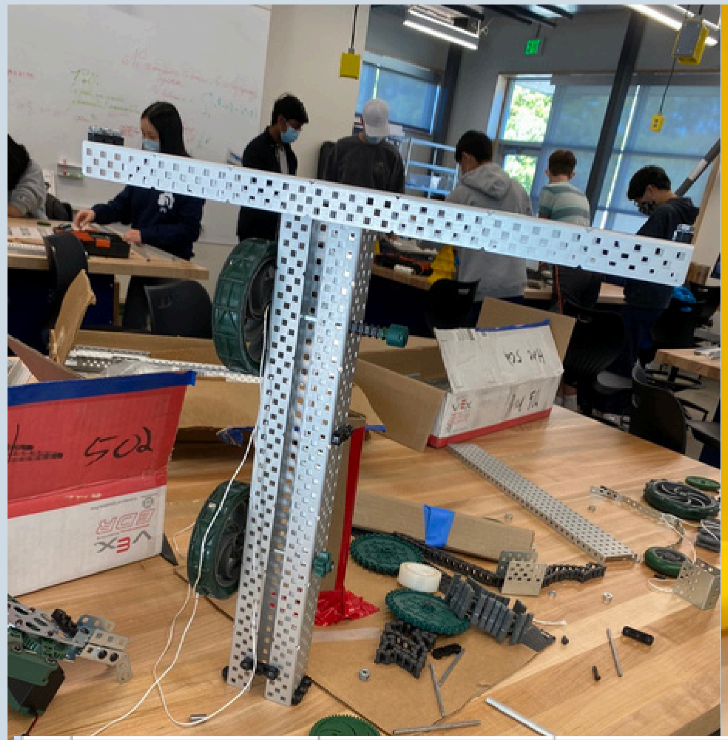
FRC ROBOTICS

As a member of an FRC robotics team, I contributed to the mechanical design, prototyping, and assembly of competition robots, focusing on optimizing functionality and meeting game-specific requirements.

Key Contributions:

- Gearbox Design: Designed and prototyped gearboxes to increase the torque of a robotic arm, experimenting with configurations using spur gears and linear actuators.
- End Effector Development: Created and refined the end effector for the arm, enabling precise handling of competition elements.
- Mechanical Lift Design: Designed a lift mechanism to position cones at specific heights, ensuring compliance with competition rules.
- CAD Modeling and Prototyping: Used SOLIDWORKS for designing robot components and leveraged 3D printing and laser cutting for rapid prototyping.
- Manufacturing and Assembly: Built and assembled robot components and competition obstacles using workshop tools such as the drill press, bandsaw, and general hand tools.

This experience enhanced my skills in mechanical design, rapid prototyping, and collaborative problem-solving, while providing hands-on exposure to manufacturing and assembly techniques.



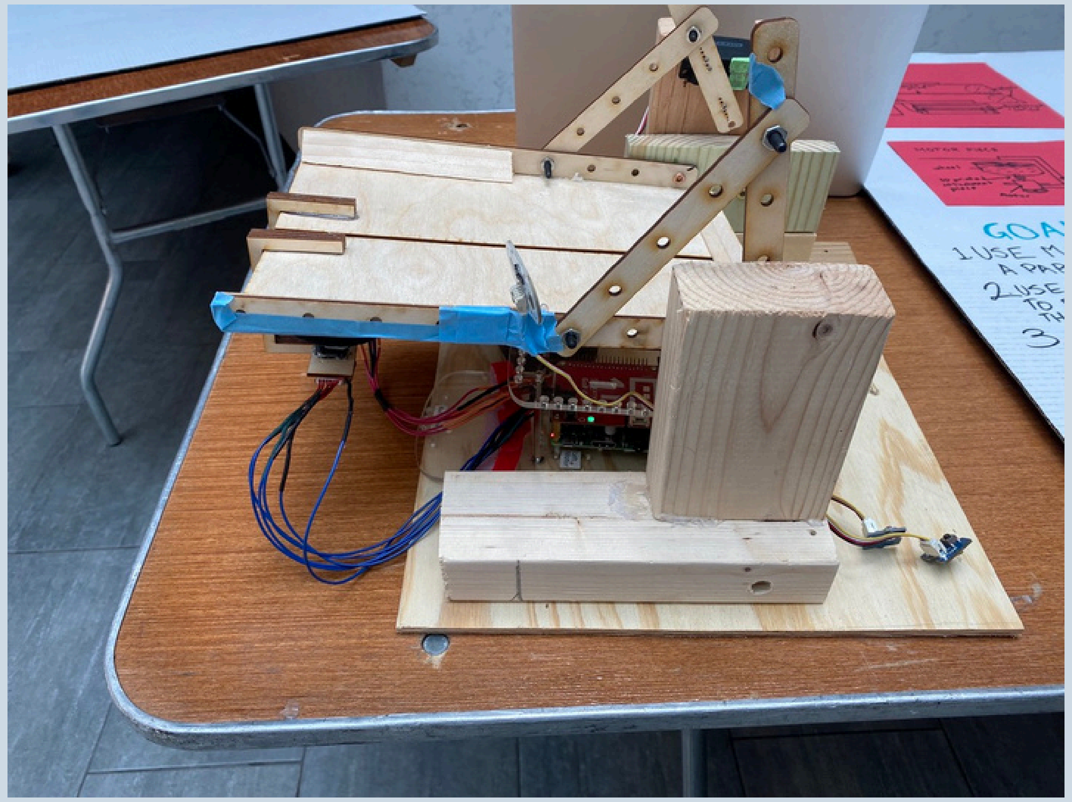
Linear Mechanism

	Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)
Falcon 500	6380	4.69	257	1.5

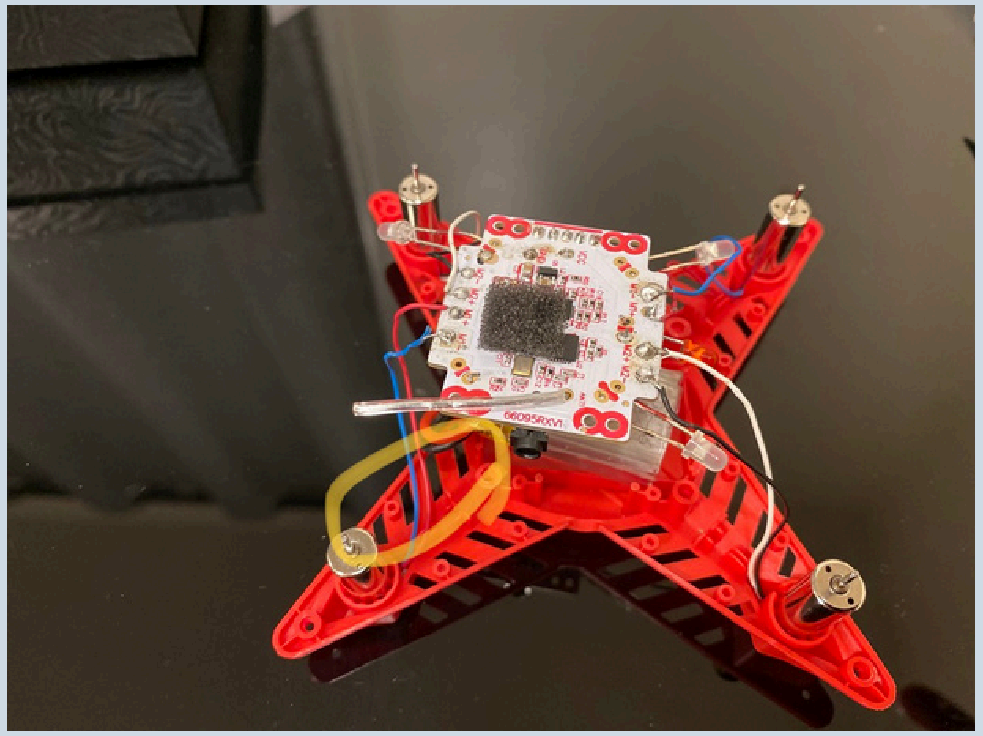
# Motors per Gearbox	Gearbox Efficiency	Travel Distance (in)	Applied Load (lbs)	Pulley Diameter (in)
1	80%	17.9	140	0.69

Driving Gear	Driven Gear		Elevator Linear Speed	Arm Time to move Travel Distance
14	40	No Load:	22.4 in/s	0.80 sec
30	34	Loaded:	19.2 in/s	0.93 sec
24	76			
1	1			
10.25 : 1	<-- Overall Ratio		Current Draw per Motor (loaded)	Stall Load
			30.39 amps	990.54 lbs

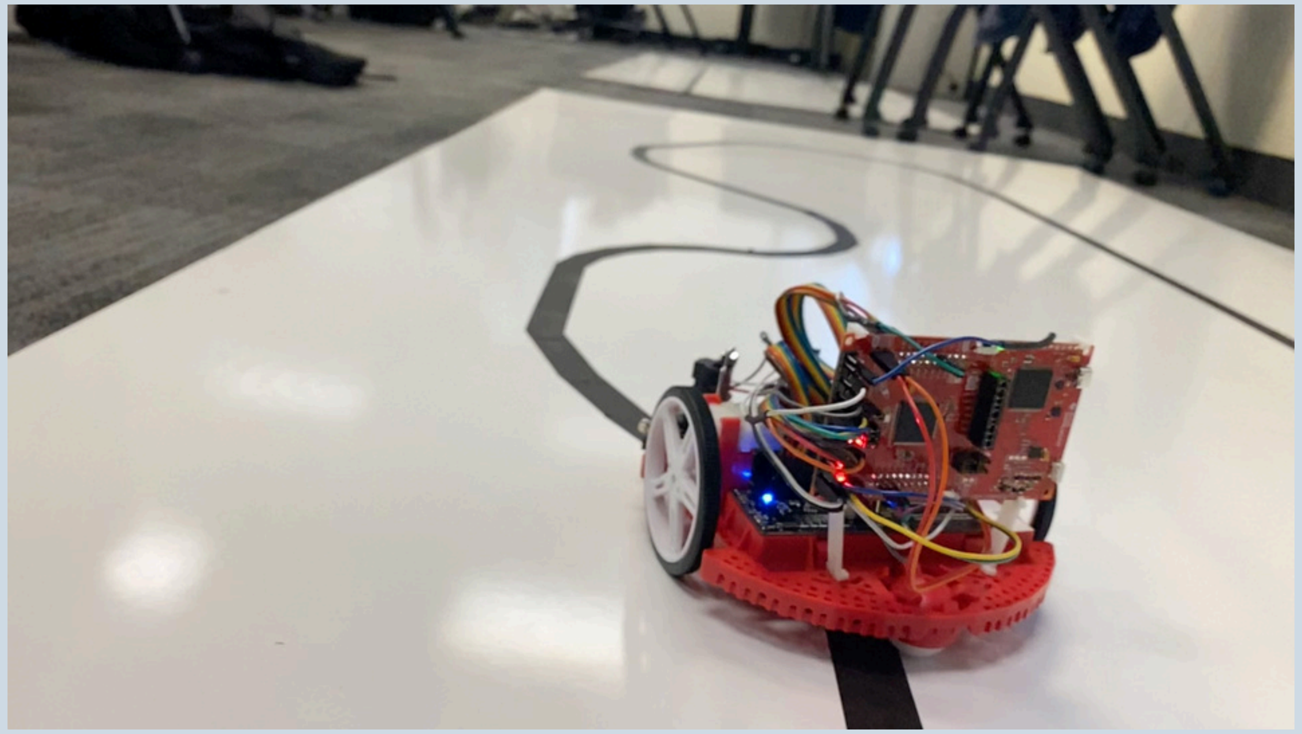
OTHER PROJECTS BEFORE COLLEGE



As part of a Tufts pre-college program, I designed and built an automatic airplane deployer. The system used servos to control the launch angle and a linkage mechanism to lift the weight of the tarmac. It featured two counter-rotating motors to generate a push force, enabling smooth and controlled airplane launches.



As president of the Aerospace Club, I led the assembly of a remote-controlled drone, including soldering the electrical board and integrating all components. Through this project, I gained insights into drone physics, propeller dynamics, and control optimization using stick controls.



In a data structures and embedded systems course, I developed a path-following robot using C, leveraging a color sensor for navigation. The project focused on fundamentals of robot coding, including memory allocation, binary and hexadecimal operations, and writing to specific pins. I implemented motor control techniques such as pulse-width modulation (PWM) and duty cycles to optimize performance. Through iterative programming and testing, I maximized the robot's speed and sensor-reading efficiency, culminating in a competition to achieve the best performance.