Team T1L2
Solar Powered Electric Scooter

APSC-171 Engineering Drawing and CAD/CAM

Team Members

STRUCTURAL

Lara Boljuncic

Charlotte Loosemore

William Perrier

MECHANICAL

Kyle Giroux

Janiecke Gordon

Keira Page

ELECTRICAL

Axel Bendl

Hasan Mohammad

Yvette Morris

MANUFACTURING

Geneviève Bell

Elissa Drayton

Introduction

Key features of our scooter:

- Solar Panel
- Remote Control
- Aerodynamic Visor
- Energy-Efficient Motor

Structural Sub-Team

Lara Boljuncic

Responsibilities:

- Base
- Back Housing Lid
- Base - Back Housing Revision
- Structural Assembly

ST

Structural Sub-Team:

Charlotte Loosmore

Responsibilities:

- Team Leader
- Designed Back Housing
- Base - Back Housing Tab and Slot
- Structural Assembly

ST

Structural Sub-Team

Responsibilities:

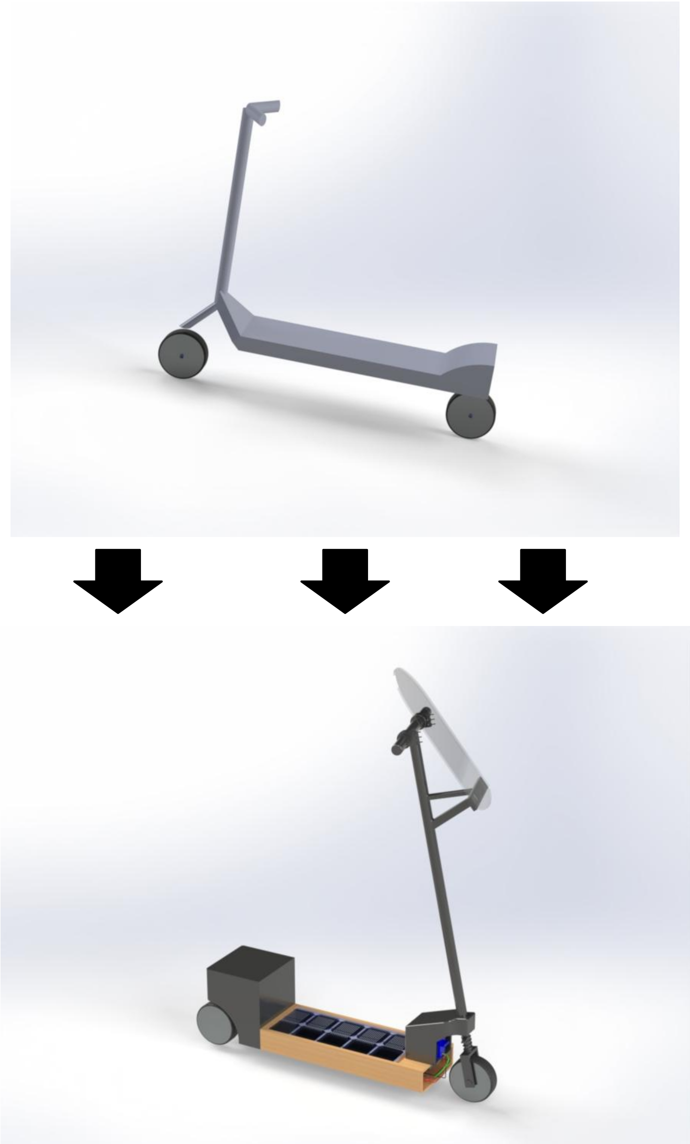
- Front mount
- Front stem assembly
- Visor
- Steering system
- Assembly of structural parts

William Perrier

ST

Initial Design (Structural Assembly)

- The Structural subteam began by visualizing the structure, they built a mock scooter to visualize the size of the major components.
- In the actual assembly, they built all parts of the structure including:
- Base, Back Housing, Stem, Stem Mount
- Designed parts to be manufactured easily



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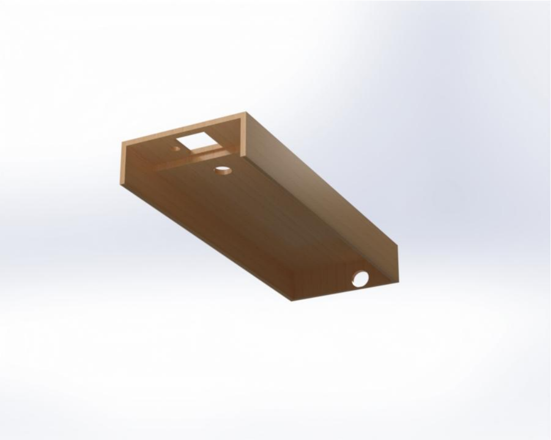
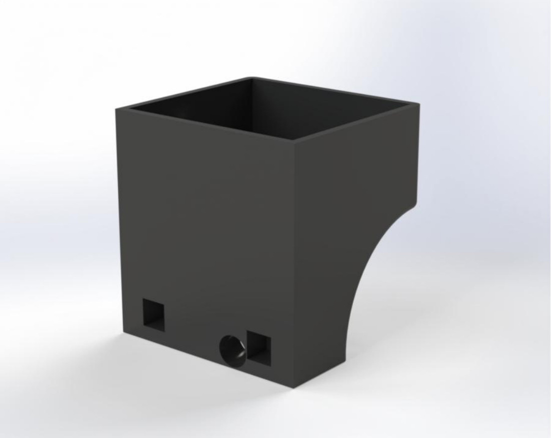
Base and Back Housing

- The Base and Back housing were initially designed to optimize the structure of the scooter.
- The team realized that these parts would not manufacturer well. Therefore, the team redesigned these two parts to be easier to manufacturer.
- This includes: Tab and Slot, base not being all one part, housing became easier to cut in half





Stem, Mount, and Visor

- The Mount required many redesigns over the length of the project, from a simple bar attaching the base to the stem to holding a complex steering system.

- The Mount has a space for the servo motor, along with all necessary routing holes. It attaches to the base through tab and slot.

- The Stem is hollow to accommodate all electrical wires, and attached to it is also the mount for the visor

- The visor is meant to protect against the weather. Although it may not shield the whole body, it protects the upper body and face from any wind, water, or dirt that comes from the street.

ST

Refinement and Final Design

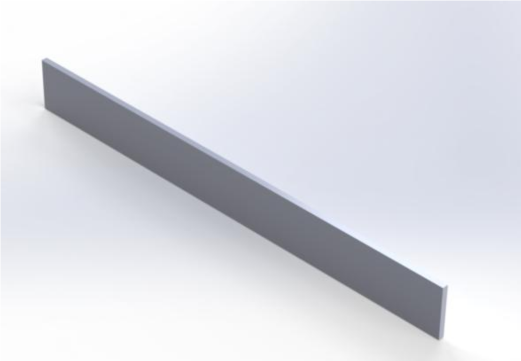
- Redesign for manufacturing

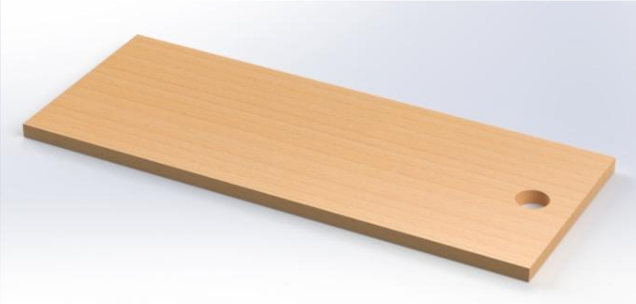
- Front stem
  - Changed to be 3 pieces
  - Shorter and more angled
  - Wider inner diameter/thinner walls
- Front stem mount
  - Sharper angle

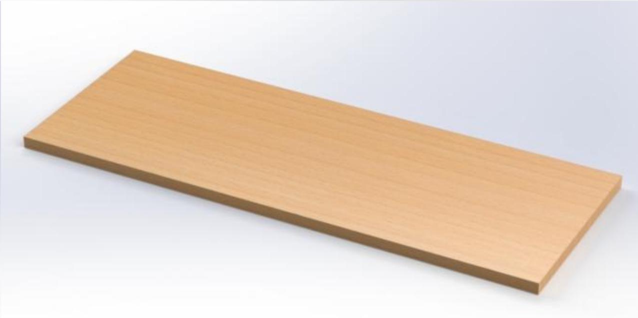
ST

Refinement and Final Design

- Base
  - Multiple pieces
  - Tab and slot
  - Side walls separate
  - Thicker for battery







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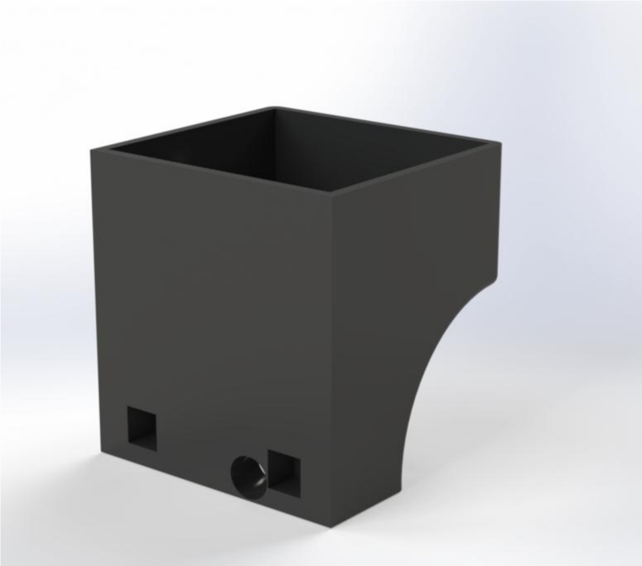
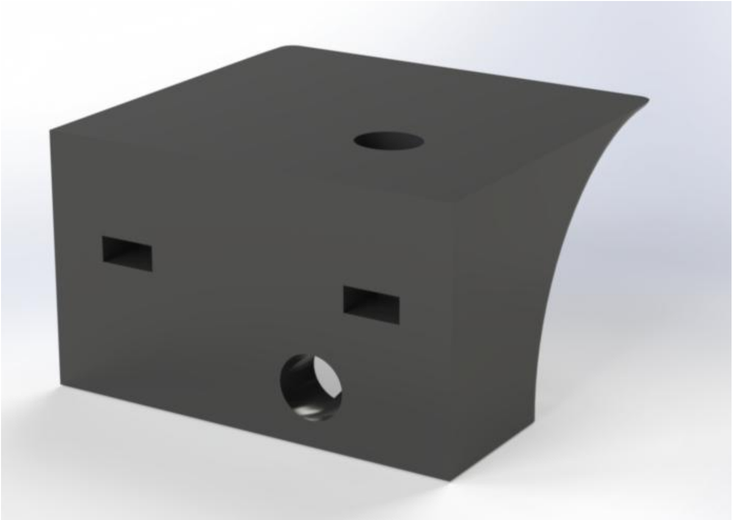
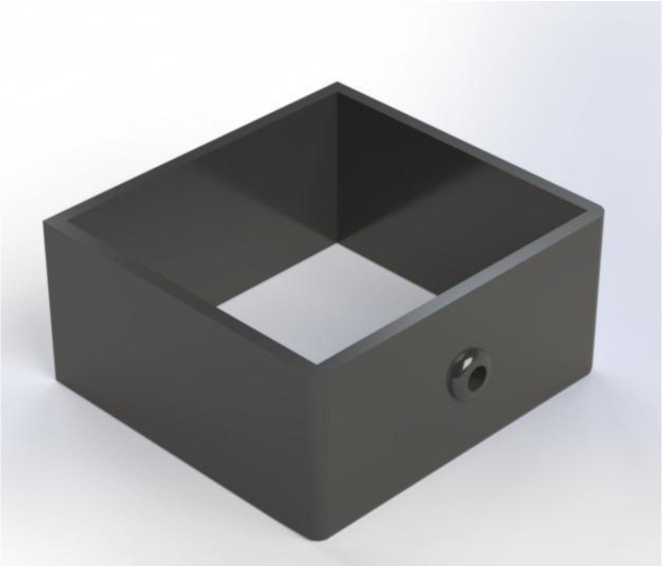
Refinement and Final Design

- Back housing
  - Two separate parts for printing
  - Tab and slot
  - Swept feature





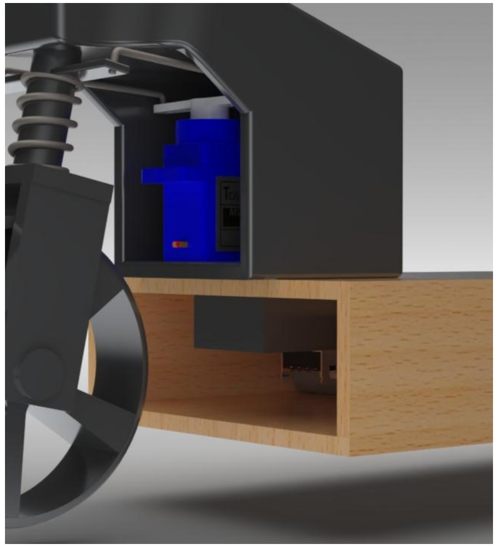


ST

Shape Optimise

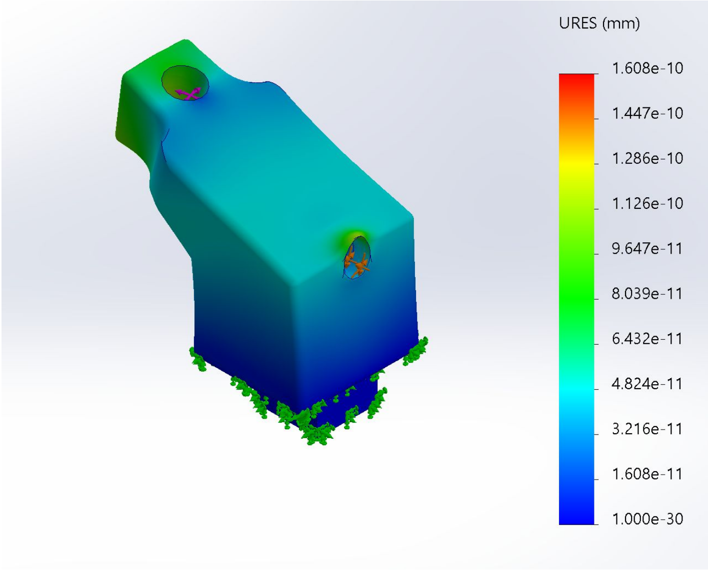
- The front mount serves as a connection between the base of the scooter and the stem assembly.

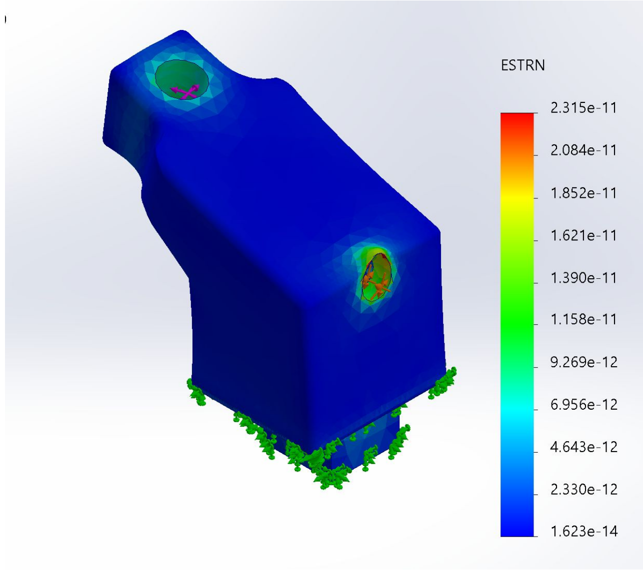
- The servo motor used in order to control the remote control steering sits inside of the main housing. This meant that it must be extremely wide to allow the servo arms to fully rotate.

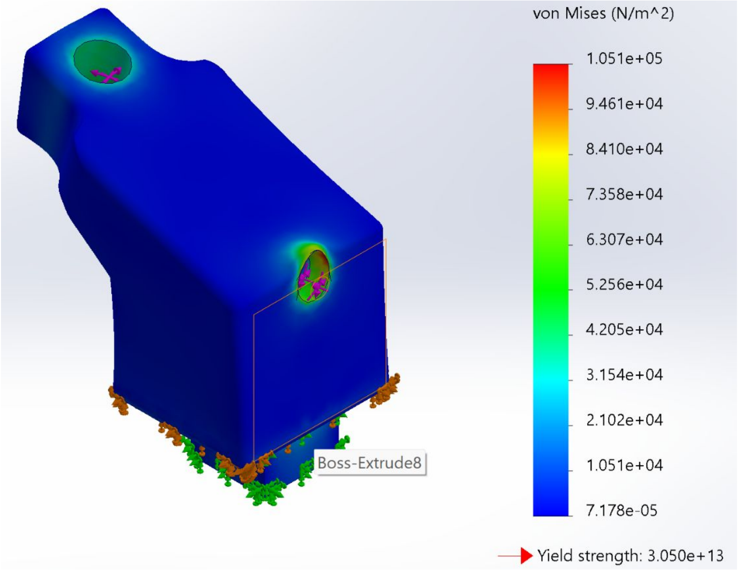


Shape Optimise

- The main stresses on the component are from supporting the weight of the driver and supporting the stem where it rests upon the mount.

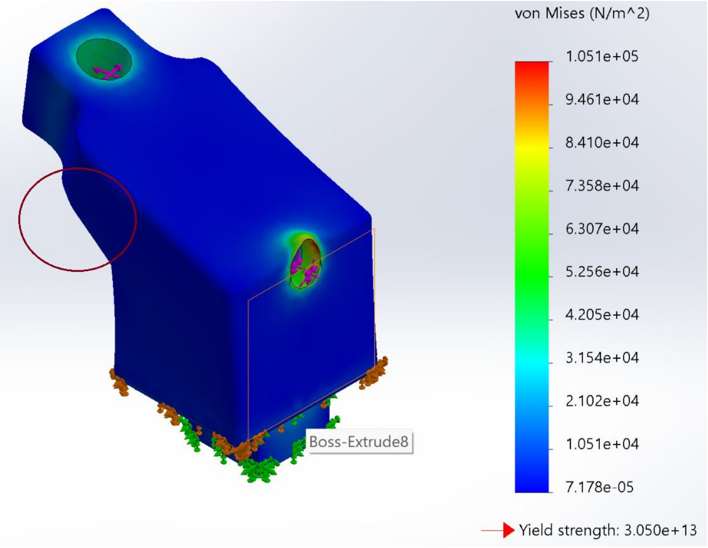


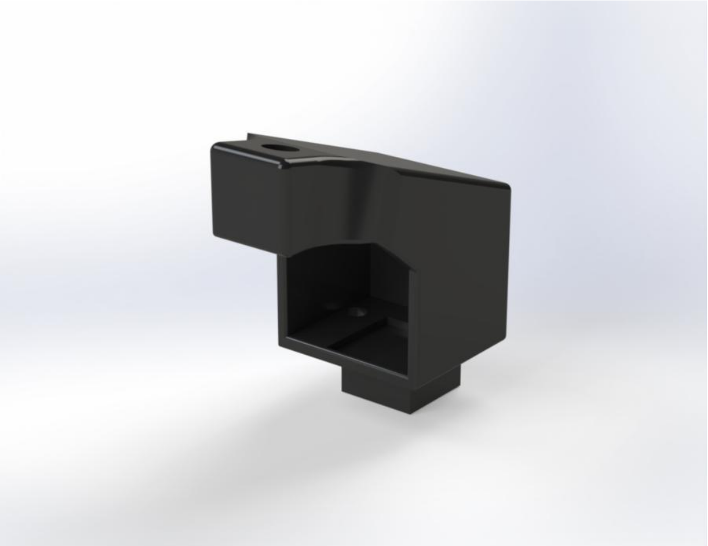




Shape Optimise

- This piece is greatly limited in its design due to the necessity of a steering system which means the possible changes for strengthening the design are few. One possible change could be elongating the supporting flanges which connect the walls of the main housing to the stem connection.





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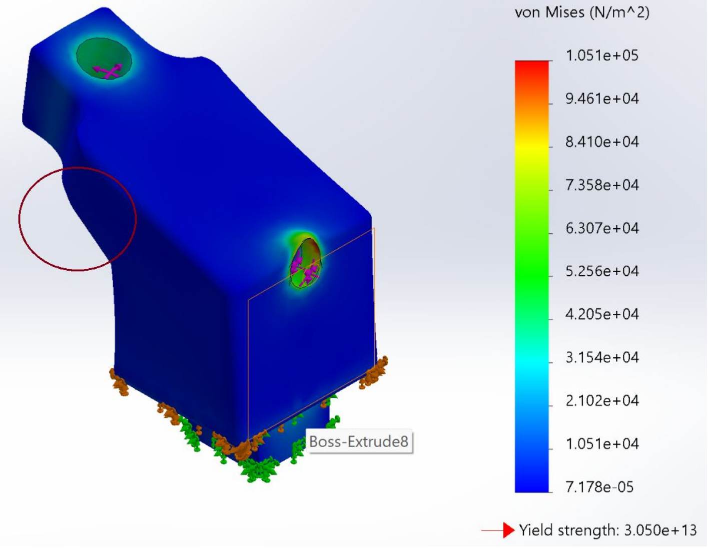
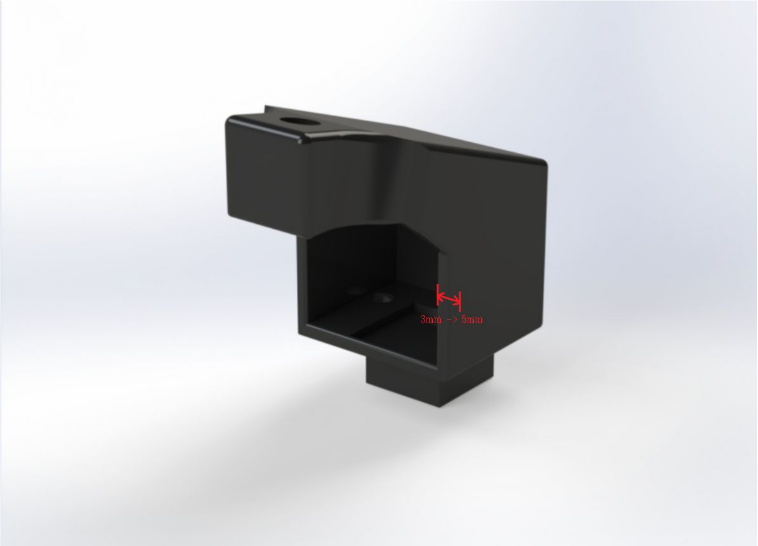
Shape Optimise

- Another possible solution would be thickening the walls of the main housing. The standard three millimeter walls could be widened to five millimeters which would greatly increase the strength of the mount.





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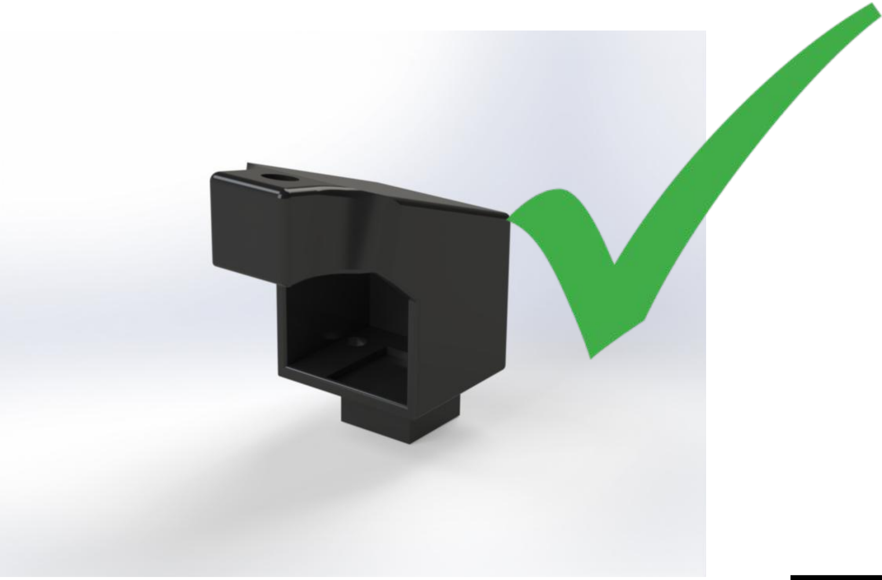
Shape Optimise

- This optimisation was not implemented in the final design due to the actual strength of the printed part. The front mount was much stronger then initially assumed and therefore did not need strengthening of the flanges.



ST

“With an ounce, move a ton”

Futuristic yet practical design, inspired by industry leaders. In order to maximize the utility with limited resources multiple functions were integrated. The front mount for example, combines the connection to the front stem and the steering system, while the back housing and the base are connected using tab and slot. The back housing also sits on top of the wheel instead of the base like a typical electric scooter.

Mechanical Sub-Team

Kyle Giroux

Responsibilities:

- Drive train
- Wheels
- Motor mounting
- Suspension
- CFD optimization

Mechanical Sub-Team

Responsibilities:

- Front Wheel Assembly
- Bar on Wheel Mount

Keira Page

ME

Mechanical Sub-Team

Janiecke Gordon

Responsibilities:

- Front wheel suspension assembly
- Assembly for front wheel support

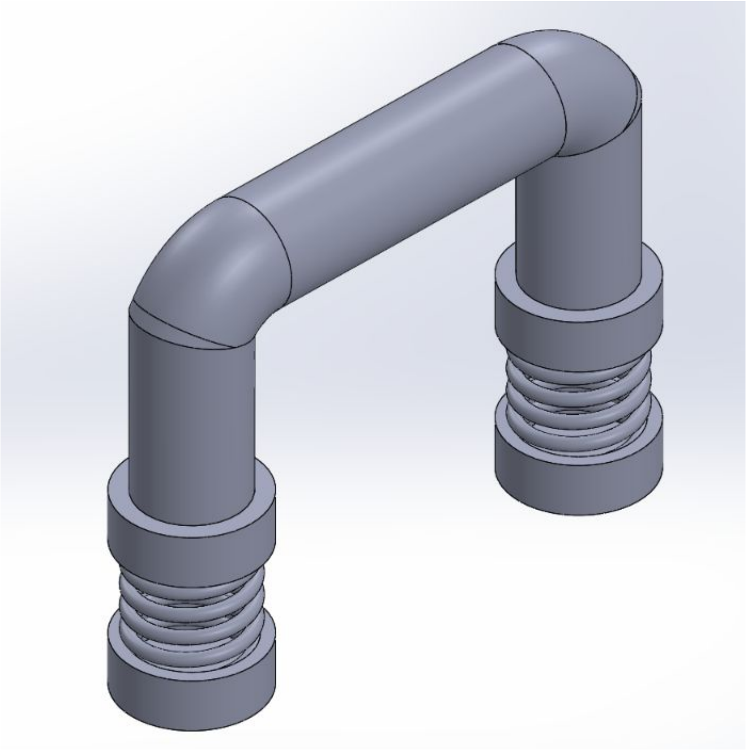
Basic Design of the Spring Suspension System

First we started by creating the foundational assembly.

Key elements:

- Bent Support Bar and Wheel Support
- Spring
- Spring Housing

This assembly served as the groundwork for refining our final suspension system



ME

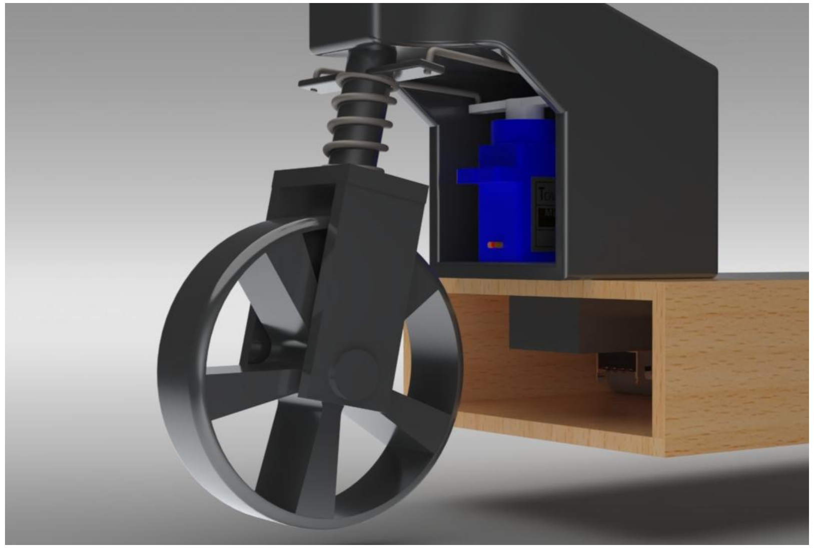
Final Design Adjustments for the Suspension System

Major design changes

- 1 spring system was used instead of 2 on each side of the wheel
- To accommodate this design change, the support bar and wheel support were also adjusted

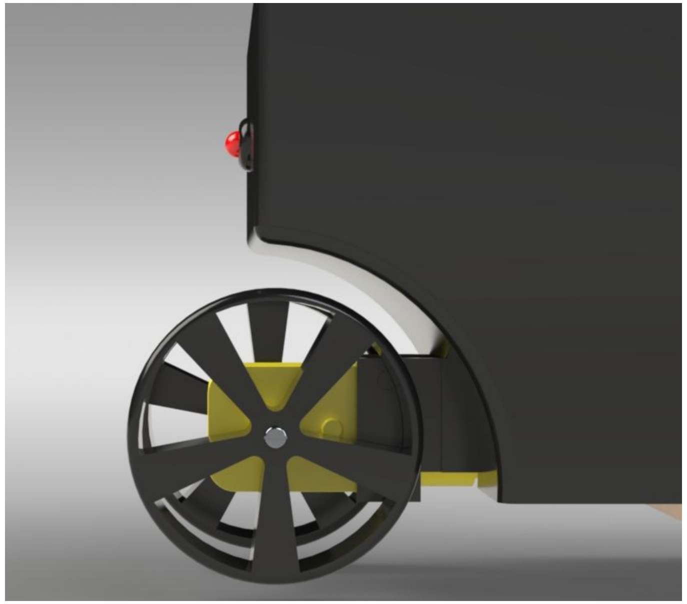
Minor Design Changes

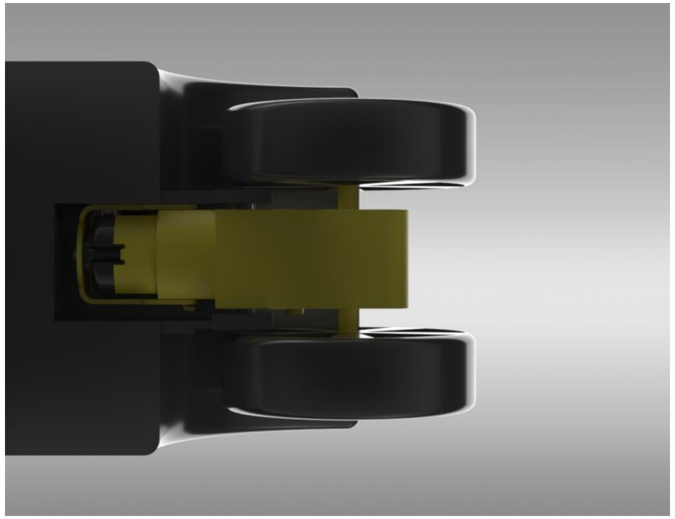
- Refinements to the support system for the front wheel were created
- Two tabs on the stem of the scooter to allow for remote controlled steering via the servo.



Motor Assembly

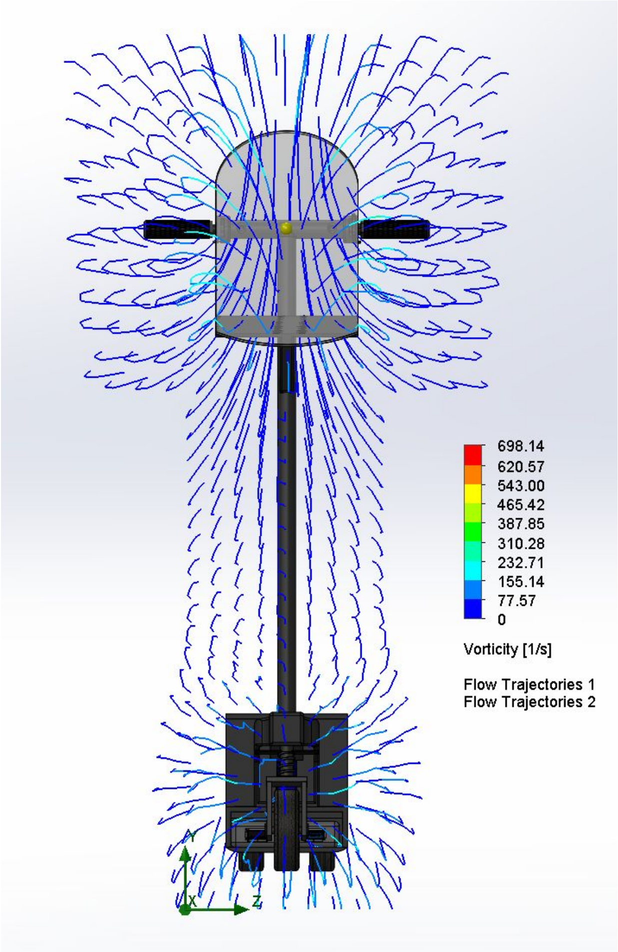
The rear wheels are attached to both sides of the motor outputs. The motor attaches to the chassis of the scooter with two tabs glued onto the rear housing. A cutout in the rear housing allowed for the wires to run up into the electric box above the motor. All the parts for the motor were 3D printed, making it easy to manufacture.





Computational Fluid Dynamics (CFD)

- Wind speeds of 7.5 m/s typical for a person commuting.
- Maximum force in the direction of the wind is 0.751 N.
- Surface area of roughly 13398.14 mm squared in the direction of the wind.
- Using the equation for coefficient of drag with the above values and an air density of 1.225kg/m cubed. The calculated drag coefficient is roughly 1.63 which is a bit high for a scooter with a person.



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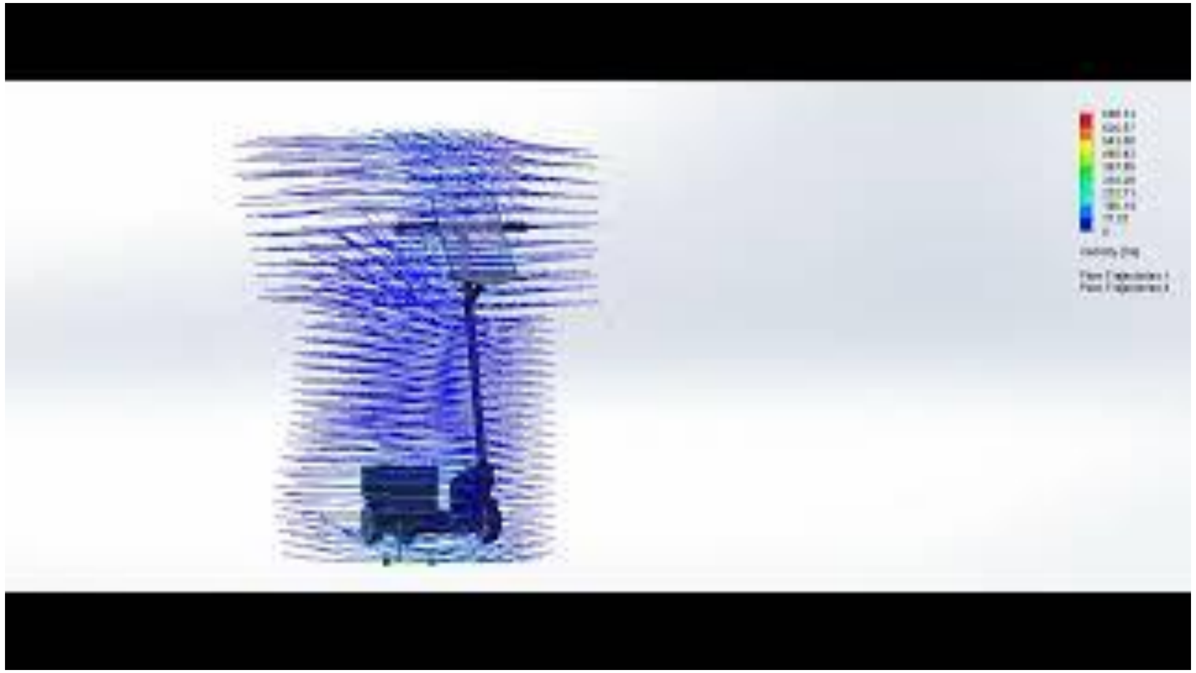
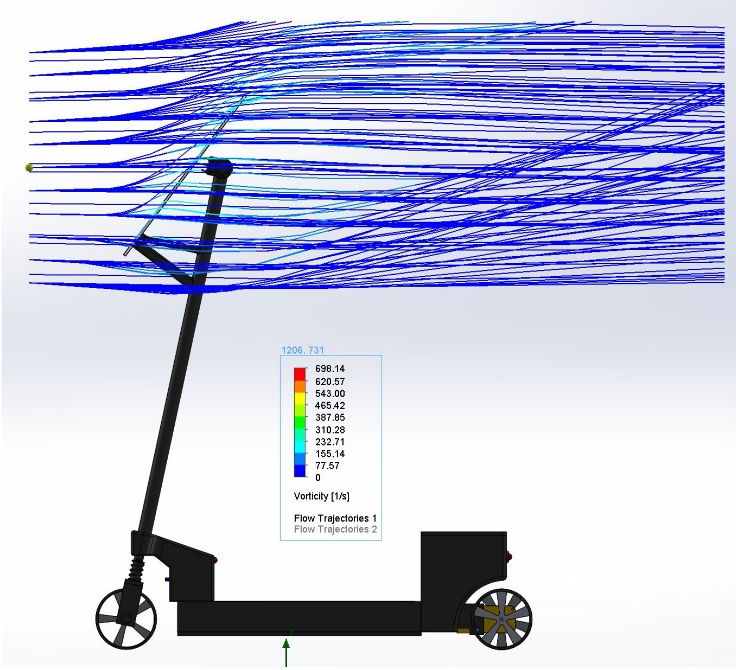
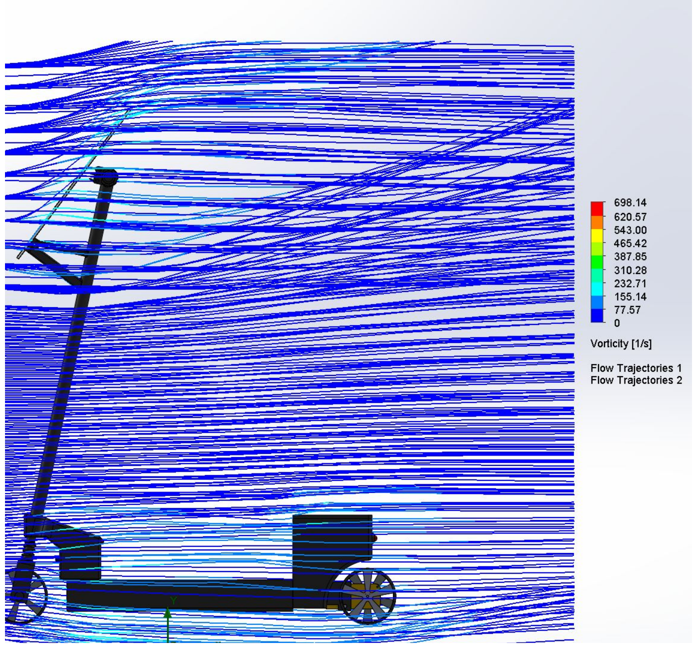
CFD Animation







CFD Optimization

Looking at the flow trajectories it is clear that we need some sort of cover on the bottom compartment to prevent wind from going straight into the battery and handlebar attachment.

The front windshield could be redesigned to let the air flow better across it and passed the rider. We could also work on making the wind not blow up from the windshield into the rider.

If we change the windshield to go further down and angle it to direct wind to the sides we could significantly reduce windflow onto the rider. The main reason this wasn't done was to keep the design simple and have a nice overall shape.

Electrical Sub-Team

Axel Bendl

Responsibilities:

- Arduino Programming
- Remote Control
- TinkerCAD Electrical Circuitry
- Breadboarding and Soldering
- Sourcing Electrical Components

- Solidworks Controller Assembly
- Solidworks Handlebars and Solar Panel Parts

Electrical Sub-Team

Hasan Mohammad

Responsibilities:

- Sourcing Electronic Component models
- Arranging electronic parts in model
- Designing electronic schematic and routing wires in solidworks
- Soldering and connecting components
- Assembly of final design

Electrical Sub-Team

Yvette Morris

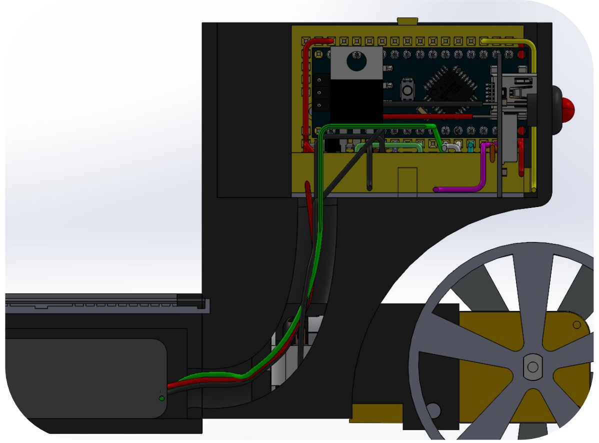
Responsibilities:

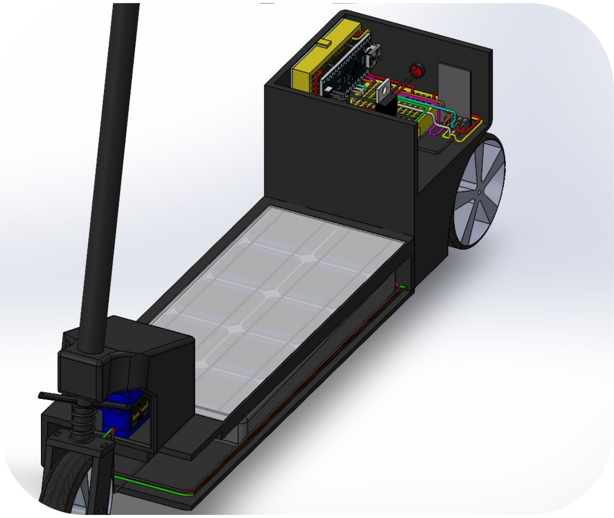
- Setting up version control through GitHub
- Slicing STL files and printing them
- Sourcing electrical components
- Soldering and assembly of final design

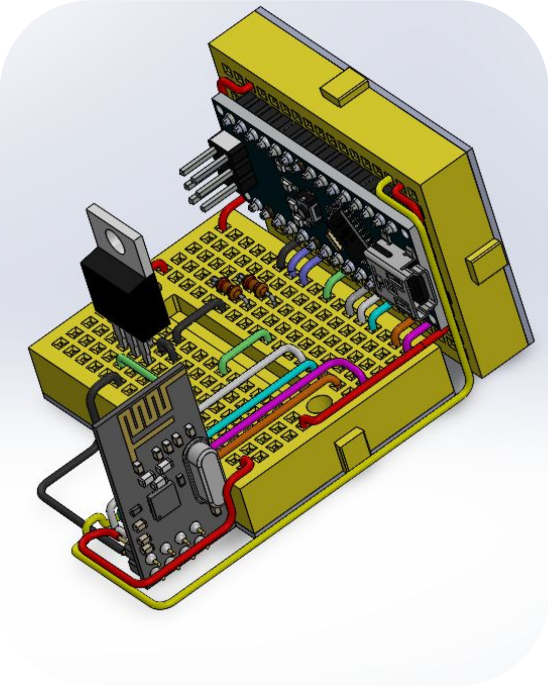
Initial Electrical Design and Routing

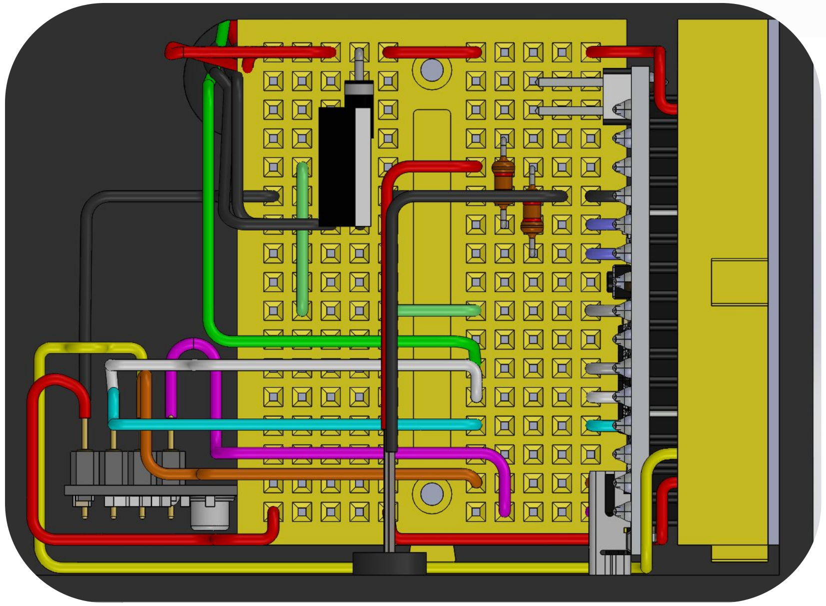
Initial design included:

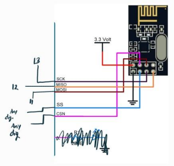
- Potentiometer speed control
- Signal LEDs
- Servo Steering
- Solar Charging
- Remote control

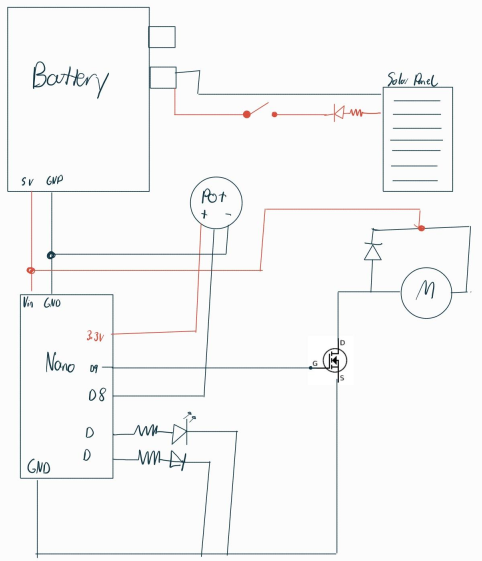












Motor Control

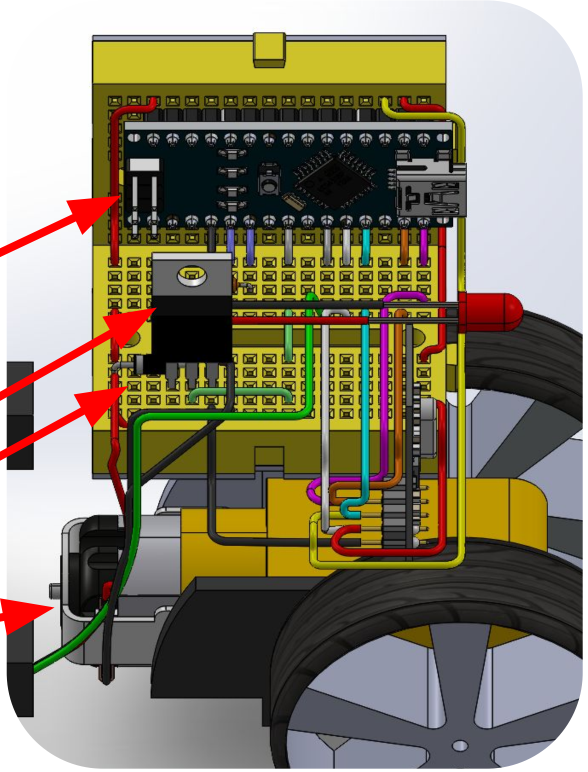
Key Components:

Arduino Nano

Mosfet Transistor

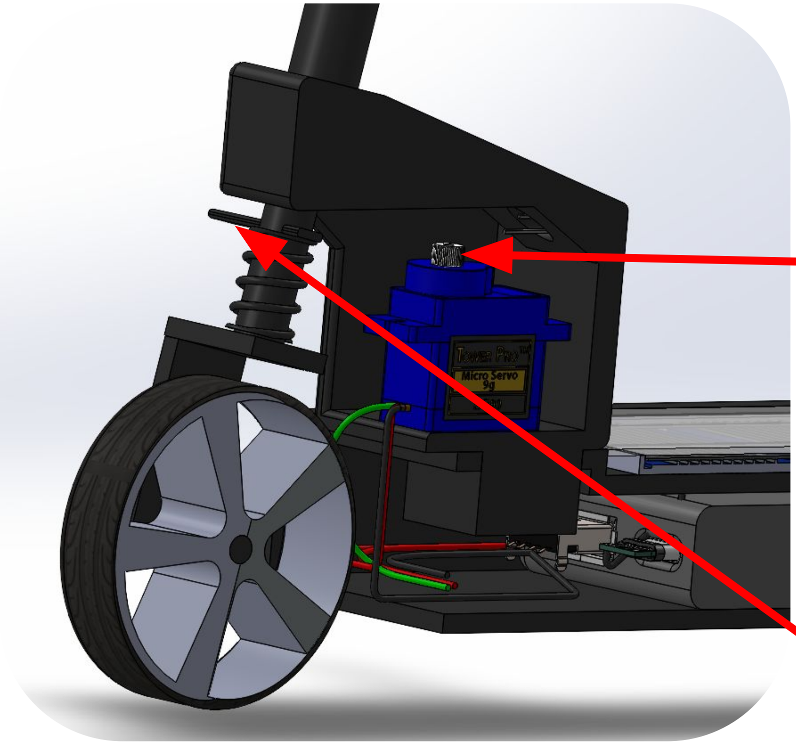
Flyback Diode

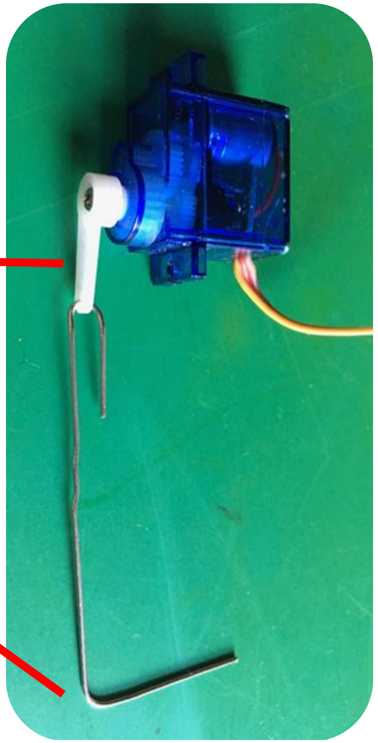
Hobby Motor



MOSFET allows arduino to regulate speed using PWM, allowing motor to take large currents from battery.

Steering

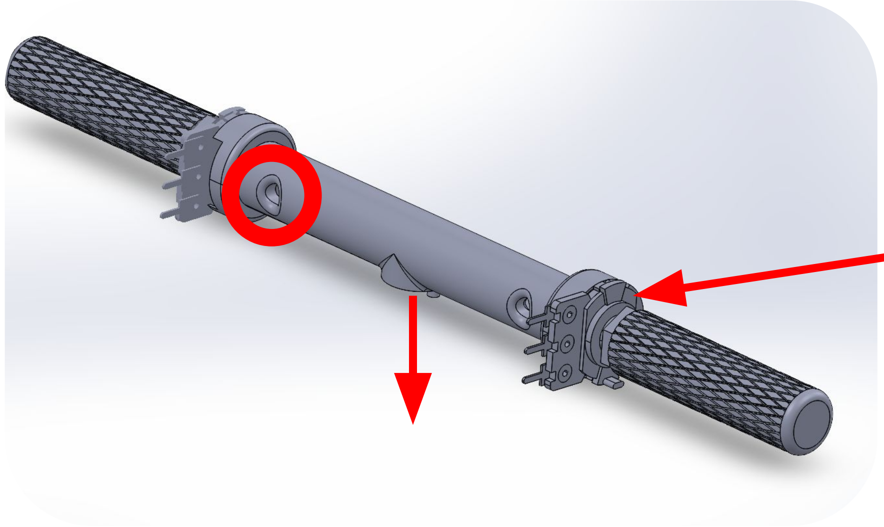


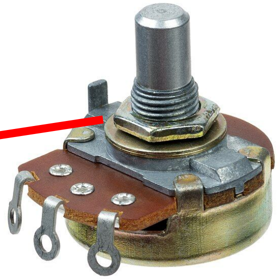


Servo motor horn connected to paper clips to pull the steering column left and right.

EL

Speed Control

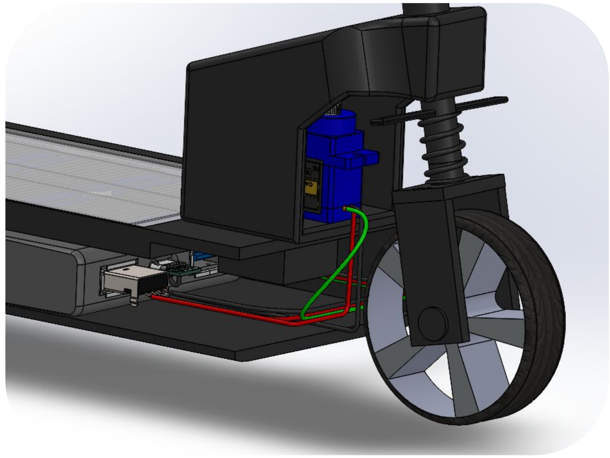




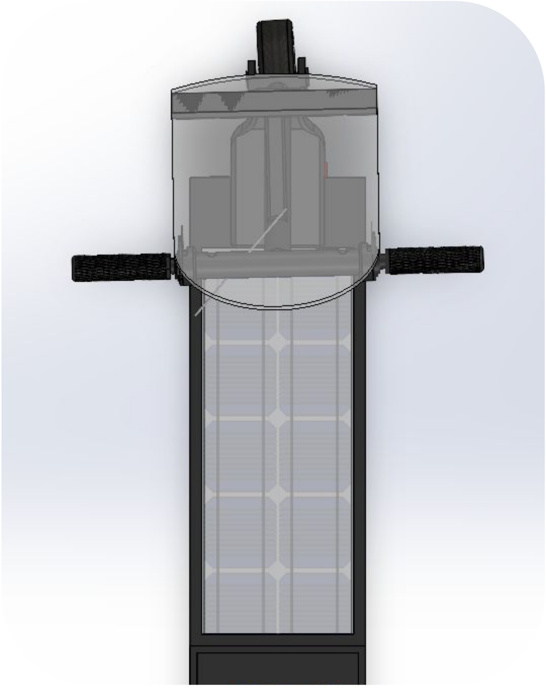
Potentiometers embedded in handle bars where rotation determines the motor speed—unless in RC mode.

Holes and channels in the handlebars for discrete wiring to the rear housing.

Battery and Power



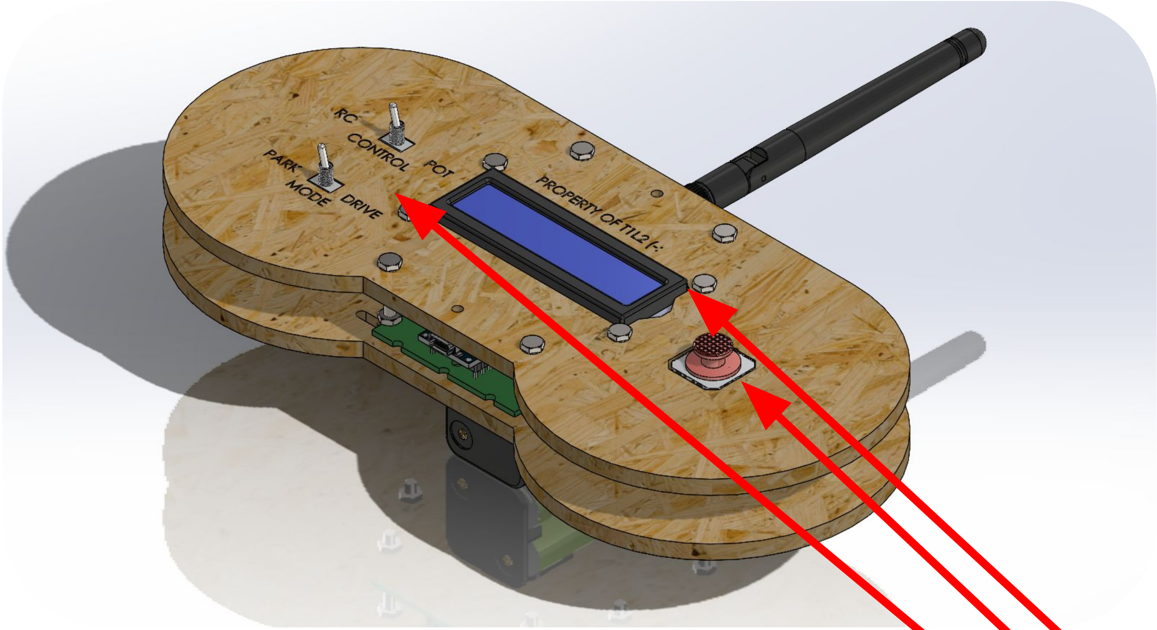
Connected solar panel to battery via a simple charging circuit.

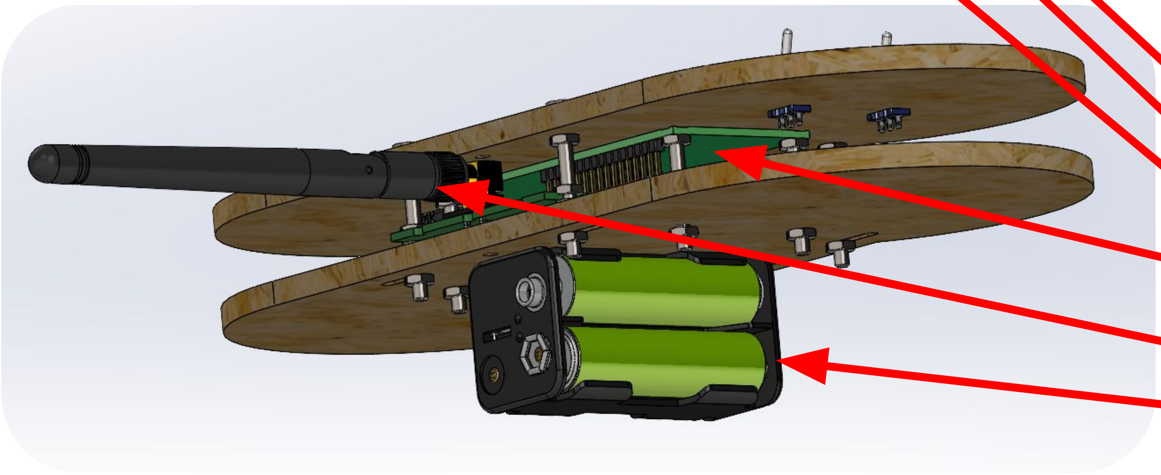


Utilized a diode to control current flow and step down voltage below 5V for safe charging.

EL

Remote Control & Logic





16x2 LCD

2 Axis Joystick

Lever Switches

Circuit Board (Nano)

RF24L01 PA LNA

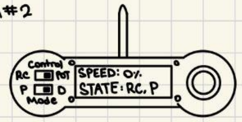
Battery Pack

States

SWITCH #1 (control)	RC control (default)	ControlState = 0
	POT control	ControlState = 1
SWITCH #2 (mode)	Parked (default)	modeState = 0
	Drive	mode State = 1

Remote Controller interface Components

Switch #1 & Switch #2
Antenna
Mini LCD
JoyStick



Scenarios

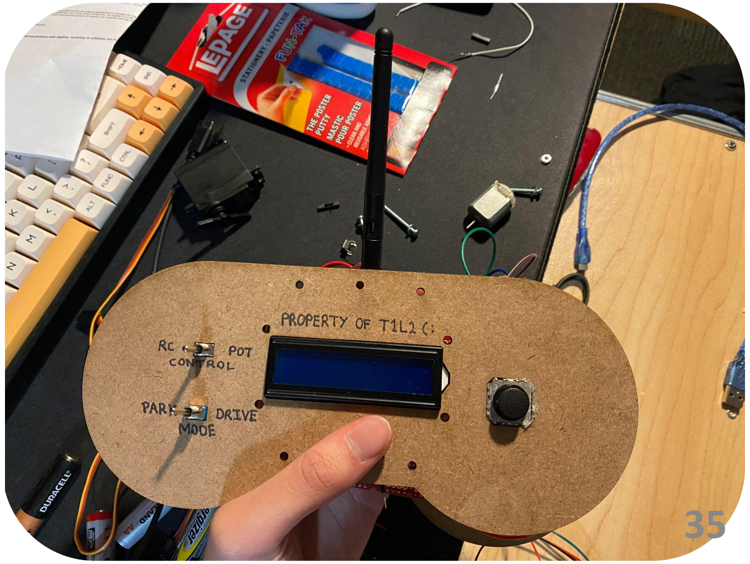
		STATE Ø RC and Parked	STATE 1 RC and Drive	STATE 2 POT and Parked	STATE 3 POT and Drive	EXTRA INFO
INPUTS	Switch #1	OFF	OFF	ON	ON	* when control
	Switch #2	OFF	ON	OFF	ON	Set to POT,
	Joystick x	ON	ON	OFF*	OFF*	force servo
	Joystick y	OFF	ON	OFF	OFF	to 90°,
	Potentiometer	OFF	OFF	OFF	ON	Straight line
OUTPUTS	White LED	ON	ON	ON	ON	* when Speed
	RED LED	ON	OFF*	ON	OFF*	=0 in drive
	SERVO	0°–180°	0°–180°	90°	90°	mode, turn
	MOTOR	TRANSISTOR: 0%	TRANSISTOR: Y%	TRANSISTOR: 0%	TRANSISTOR Y%	RED LED
	LCD Row 1	SPEED: 0%	SPEED: x%	SPEED: 0%	SPEED: x%	ON, override
	LCD Row 2	STATE: RC, P	STATE: RC, D	STATE: POT, P	STATE: RC, D	defaul condition
RC STATE	Transmitter start	writing	writing	Reading	Reading	RC Control
	Reciever start	Reading	Reading	writing	writing	POT control
	Transmitter end	Reading	Reading	Reading	Reading	Display to LCD
	Reciever end	writing	writing	writing	writing	updating controls

RF module draws more current than the arduino can provide, so a linear 3.3 volt regulator was soldered on the circuit board to allow the 6 volt battery pack to power the module.

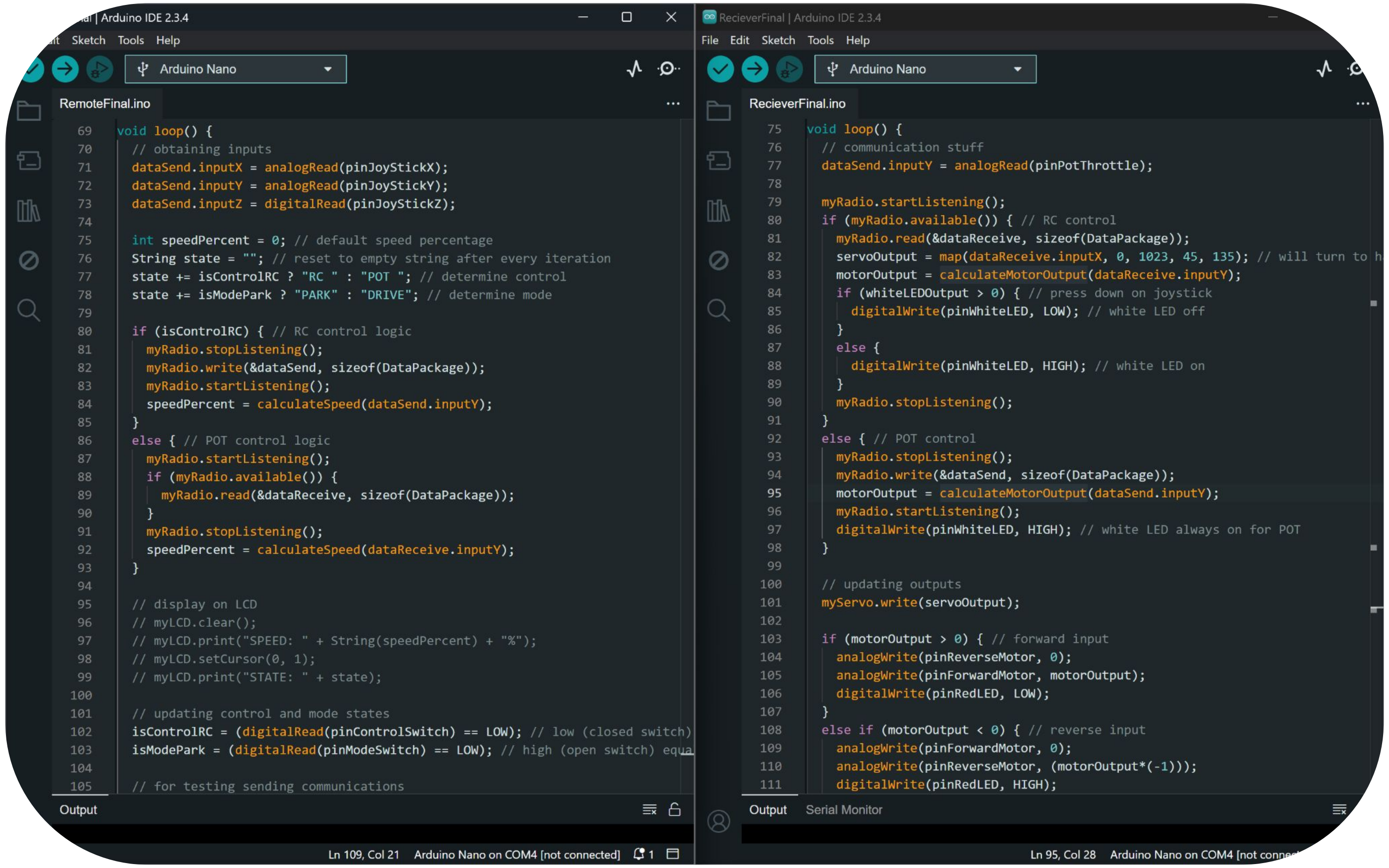
EL

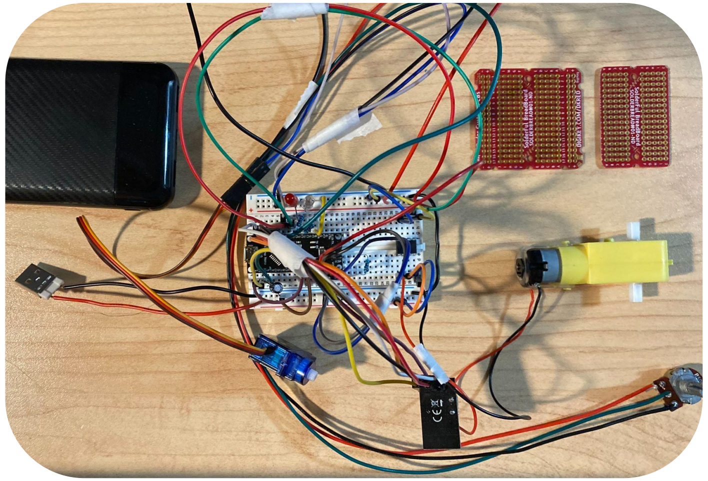
Building and Testing Remote Control

- Two switches control the states
  - mode (PARK or DRIVE) and the input (RC or POT).
  - In RC mode, the joystick inputs override the potentiometer input.
- LCD displays the speed and state of the scooter.
- Frame was laser cut and fastened with M3 screws and nuts.



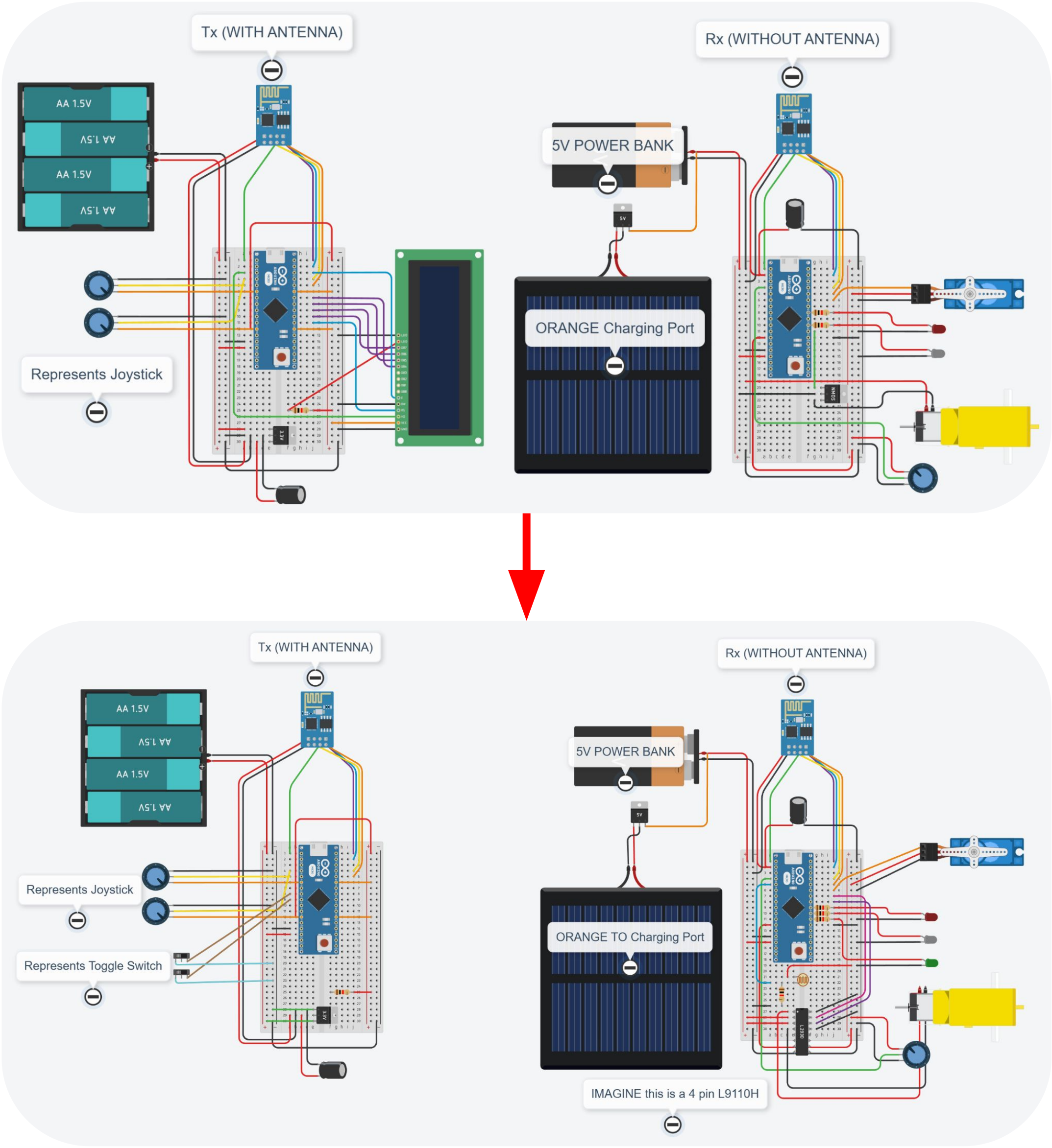
Building and Testing Remote Control





Refinements and Final Circuitry

- Introduced decoupling capacitors to remove noise.
- Introduced front, back, and charging LEDs.
- Removed transistor and utilized H-Bridge IC.
- Modified charging circuit to only involve linear 5V regulator.
- Removed LCD due to conflicts over SPI pins.



“With an ounce, move a ton”

We prioritized an efficient and compact design

- Routed cables through body and handlebars to shield components.
- Simple remote control construction (laser cut and screws).
- Organized components to minimize wires needed.
- Multiple parts connected through one set of cables.
- Soldered components to perfboard to create more sturdy electronic fit.
- Simplified solar panel to power bank charging circuit.
- Simple steering mechanism with paper clips.

EL

Manufacturing Sub-Team

Geneviève Bell

Elissa Drayton

Responsibilities:

- Final SW Assembly
- SW Animation
- PDF files for laser cut
- STL files for 3D print
- Building Prototype

MA

Initial Design (what was submitted for CAD)

Part	Originally Intended Method of Manufacture
Base	3D Print
Stem and Handlebars	3D Print
Front and Back Housing	3D Print
Front and Back Wheel Mounts	3D Print
Screws (and other fasteners)	Buy off the shelf
Visor	Vacuum Mould
Wheels	Buy off the shelf
Electrical Components	Buy off the shelf
Solar Panel	Buy off the shelf
Battery	Buy off the shelf
Spring	Buy off the shelf
Motor	Buy off the shelf

MA

Initial Design (what was submitted for CAD)

Refinement and Final Design

- Various parts were optimized for 3D printing and assembly.
  - Back housing, wheel mounts and suspension, etc.
- Laser cut top and bottom of the base instead of 3D printing to reduce printing costs.

MA

“With an ounce, move a ton”

- Reduced unnecessary complexity by refining parts for easier 3D printing and assembly.
- Reduced reliance on screws by integrating tab and slot connections where possible.
- Designed components to serve multiple roles, reducing the total number of parts.

Demonstration of Prototype

Grand total cost: $118.30

Question and Answers

Bill of Materials

Description	Qty	Unit Price($)	Sub-total ($)
3D Printing (g)	219.91	0.10	21.99
Mannequin	1	2.94	2.94
PETG 0.02" thick, 12" x 8"	0.23	1.10	0.25
Plywood 5 mm thick, 9.6" x 16"	0.59	0.75	0.44
MDF 0.125" thick, 9.6" x 19.2"	0.37	0.68	0.25
4AA Battery Holder	1	1.98	1.98
1.5 AA Batteries	4	0.00	0.00
Potentiometer (10kohm)	1	4.50	4.50
nRF24L01 PA LNA	1	6.10	6.10
nRF24L01	1	3.70	3.70
2-Axis Joystick	1	4.05	4.05

Bill of Materials

Description	Qty	Unit Price ($)	Sub-total ($)
3.3V Regulator	1	1.02	1.02
5V Regulator	1	0.41	0.41
Capacitor (100mF)	2	0.20	0.40
Arduino Nano	2	9.82	19.64
Resistor (1kohm)	3	0.50	1.50
Half Solderbread	1	1.45	1.45
Mini Solderbread	2	1.25	2.50
L9110H H-Bridge	1	1.50	1.50
6V Solar Panel	1	7.00	9.41
5V Power Bank	1	0.00	0.00
Epoxy	1	14.46	16.20

Bill of Materials

Description	Qty	Unit Price ($)	Sub-total ($)
Coloured LED	2	0.50	1.00
White LED	1	0.91	0.91
Photoresistor	1	1.13	1.13
SG90 Positional Servo	1	2.80	2.80
DC Gear Motor 3-6V	1	4.91	4.91
3A 125VAC Toggle Switch	2	1.60	3.20
M3x30mm Screws	8	0.014	0.11
M3 Nuts	16	0.02	0.32
Wires (67x Average of 5 cm)	335 cm	0.008 / cm	2.68
		Grand Total	118.30