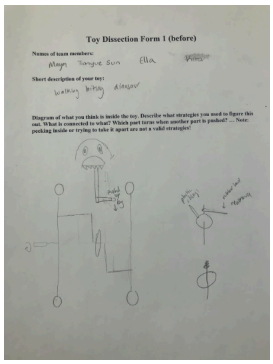
Responsive Structures Learning Portfolio

12-030, Spring 2024, Maya Beach

Learning from Class

The primary reason why I wanted to take Responsive Structures was because I enjoy thinking about how humans interact with our surroundings. Unexpectedly, this course gave me a crash course into rapid prototyping and gave me the structure to take risks in my projects.

Graphic statics and load bearing presentations affirmed my knowledge from other engineering classes, but the “Toy Dissection” activity and focus on automata challenged my thinking. It contrasted my existing knowledge of high-powered motors and mechanisms in robotics, and our small-scale prototypes made me think critically about motor selection and simple mechanisms.



Learning from Peers

Interacting with peers from different disciplines is always eye-opening and informative. In our short peer discussions, critiques, and activities, I gained a little insight into how my peers thought differently and applied their technical knowledge to the course. For instance, in conversations with design or architecture majors, form and scale were extremely important to their prototypes. For me, an engineer, I was more concerned with the movement and manufacturing (CAD/laser cutting) of my prototype. My classmates were mainly from ECE, Architecture, Design, and Computer Science. The two classmates I learned the most from were in Computer Science: Cameron, a senior, and Julie, a first year.

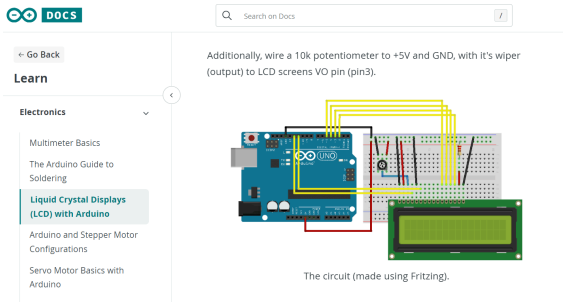
Cameron and I initially sat at the same table, so through activities and conversation we learned about each other's projects. He introduced me to Yupo paper which was a key part of my third project and helped with brainstorming early on for my second project. Cameron was absolutely meticulous with his project, the Bloombox. With minimal experience in CAD or hands-on construction, I saw his creative mind at work. He created

extremely small precision parts and his willingness to try, try, and try again until he got a product he was satisfied with was very inspirational.

Towards the second half of the semester, I sat at Julie's table. As I wrestled with the logistics of a sliding roof for my greenhouse, she sketched out a simple solution: rails. Getting input from someone who was not engulfed in the intricacies of the project was vital for my prototype! It took her a while to decide on her third project, but we had fun brainstorming all sorts of ideas. With her Computer Science background, she explained how she wanted to incorporate interesting use of a sensor. We talked about escape rooms that could spin upon entering, wardrobes that respond to hand movements, and more, and I tried to provide advice on practical implementation.

Learning from Others

Physical Computing - Zacharias



Arduino Docs

For my second project, my 'independent learning' was focused primarily on Arduino. I felt like I had a decent basis for the Arduino, but was unfamiliar with the implementation of various sensors and outputs. Online blogs, Youtube, and Physical Computing resources enabled me to explore and implement a variety of devices I had never worked with. Typically, the learning process involved following a video or wiring guide, copying code, and testing on the set-up. Oftentimes, provided code didn't correlate exactly with my set-up, or required libraries, causing me to spend more time carefully reading up on syntax and the purpose of the code. Although my understanding of the code I experimented with is more shallow than the code I have written independently, being able to comprehend these starter codes is a useful skill.

During my time experimenting with Arduino in the class, I was able to get these devices to work:

- Big sound sensor
- Number pad
- Temperature and Humidity Sensor

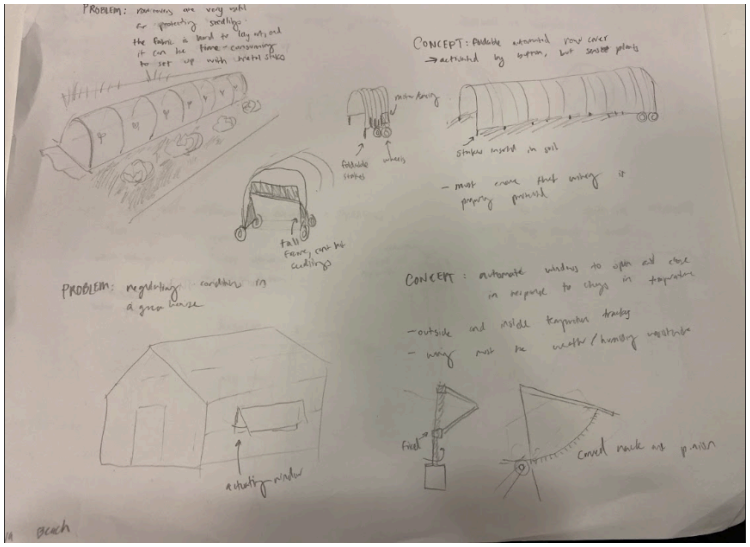
- LCD Screen
- A printer found in the “free stuff” bin (done with a friend outside of class)
- Synchronous servo motors
- Pairing two Arduinos to each other (never fully implemented)

Project Experience

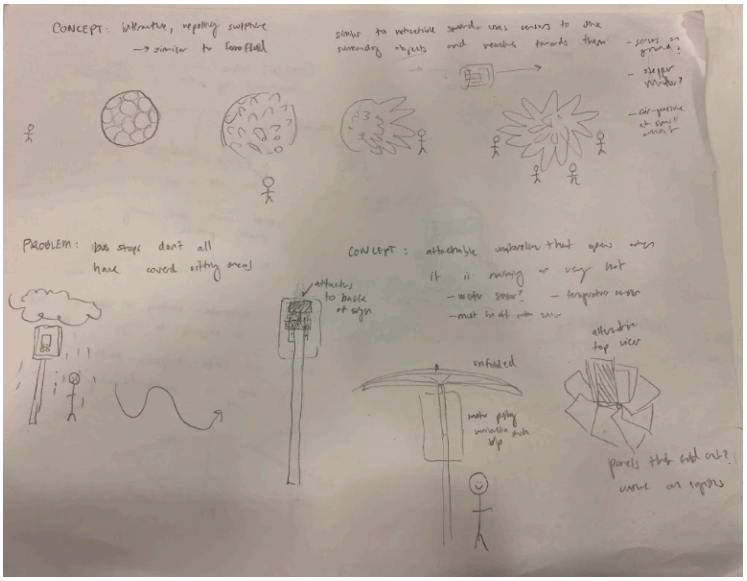
Out of everything in this class, I learned the most from my experimentation! For both projects, I spent much of my time in the laser cutting room and felt much more comfortable designing and using the machines on a variety of materials. These projects challenged me to come up with rapid solutions when things didn't go as planned.

Project 1: Conceptualization

The conceptualization stage came quite easily to me, as I imagined things in my real life. Deciding moving aspects and determining the practicality of each project took more time.



Rolling Garden Bed Cover:
Problem: Row covers are very useful for protecting seedlings, but unrolling fabric can be a long, time-consuming process
Concept: Foldable, automated, rolling, row cover activated by a button, able to sense plants
Automated Greenhouse:
Problem: Regulate growing conditions
Concept: Automate windows to open and close in response to temperature



Inflatable, Repelling Sculpture:

Problem: N/A

Concept: Interactive structure that spikes ou like ferrofluid to a magnet when someone walks near, inspired by “repel someone” prompt

Bus Stop Cover:

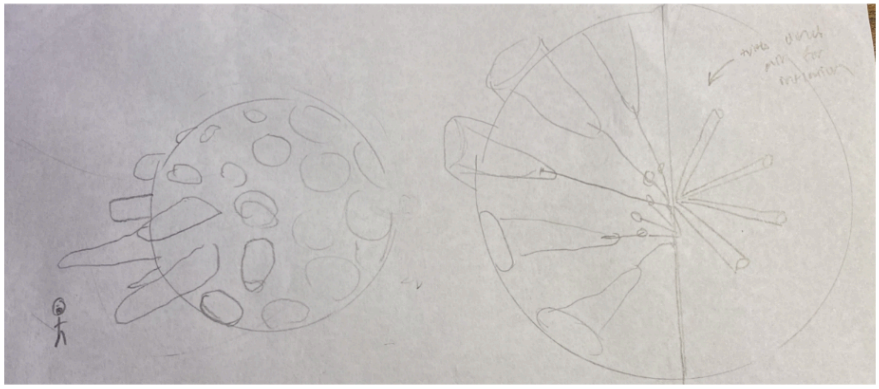
Problem: Bus stops often lack covered seating areas

Concept: Attachable, retractable umbrella that opens when it is raining or very hot, responds to rain and temperature. Could be made up of multiple plates that fold out

- My classmate Ella did this for her project, and it's interesting how similar this sketch was to her idea - great minds think alike

Project 2: Inflatable, Repelling Sculpture

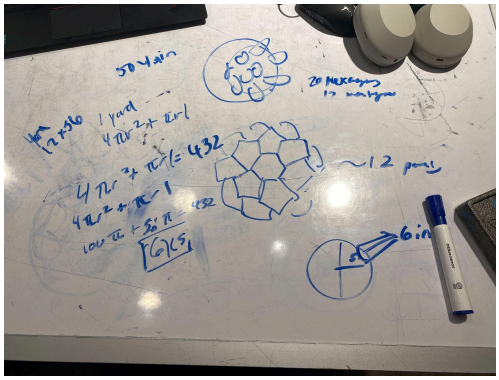
For my first project, I decided to pick the responsive sculpture idea. The idea was goofy, abstract, and ambitious.



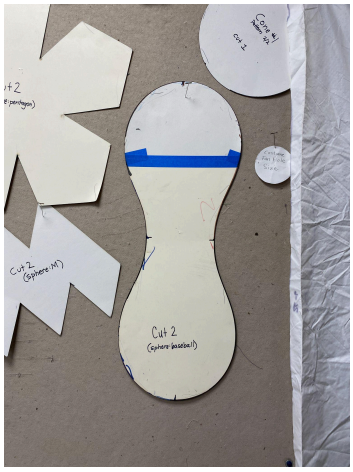
inflatable spikes pulled by string while being uninflated, allows for more intricate reconfiguration, tubes to direct air for inflation

Project information is attached here: Inflatable Sculpture Info

I spent too much time trying to figure out how to make a ball out of fabric and trying to calculate how much fabric I would use.



Initially, I made a ball in a beach ball style with a wire frame where each panel could bend independently. This was not practical for an inflatable. Advice from Olivia Robinson and my classmate from Culture of Color Teadora were very useful for redirecting me towards a practical plan. I switched gears and made a ball using a baseball template, then laser cut my cone pieces and added them to my “baseball” which had holes for each cone.



This was a long process. First, I learned that laser cutting fabric, although extremely useful, can also be quite dangerous for the laser cutter. Due to the thinness of the material and a slightly uneven bed, the laser cutter ended up dragging the plunger into the bed and bending some of the metal grate. This was an important lesson in putting stock material like cardboard below thin materials.

Second, I had to be quite patient while sewing each of the cones, and gluing and “clamping” the edges of the cone with weights made sewing much easier with the pieces stuck in place.

By the time I was done making my spiky sculpture, adding a wire frame for support and gluing strings to the cones to retract the cones, I needed to model my activation. This led me into another rabbit hole, where I had a lot of fun designing a case that involved a sliding person which turned on the inflatable fan when close to the sculpture and turned the fan off when far away. Although my inflatable did not successfully inflate, the lessons I

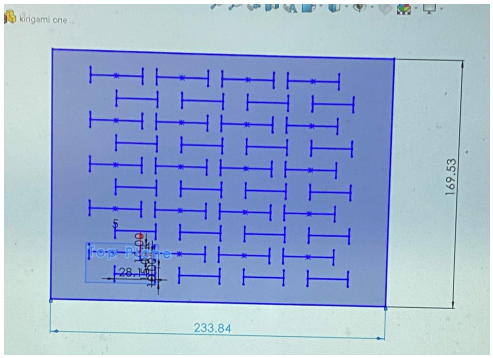
learned along the way made me feel more confident about my laser cutting abilities and excited to do some more CAD work.

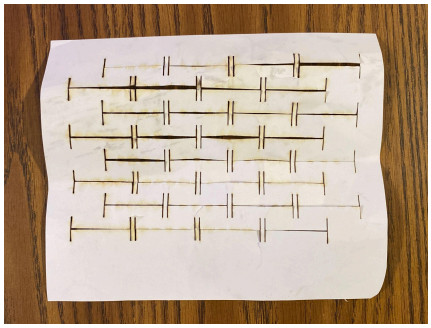
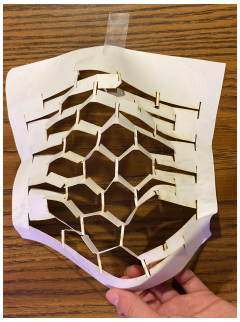
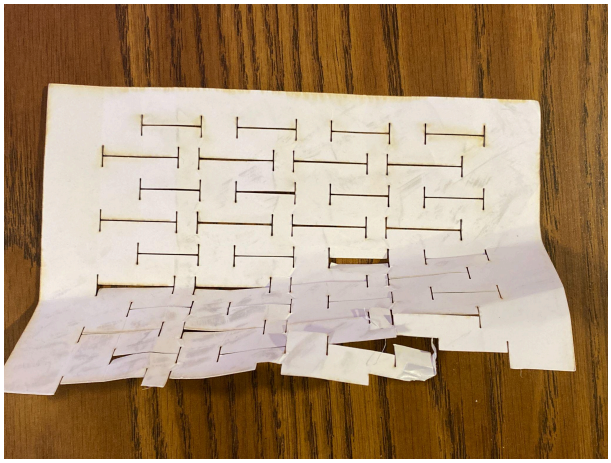
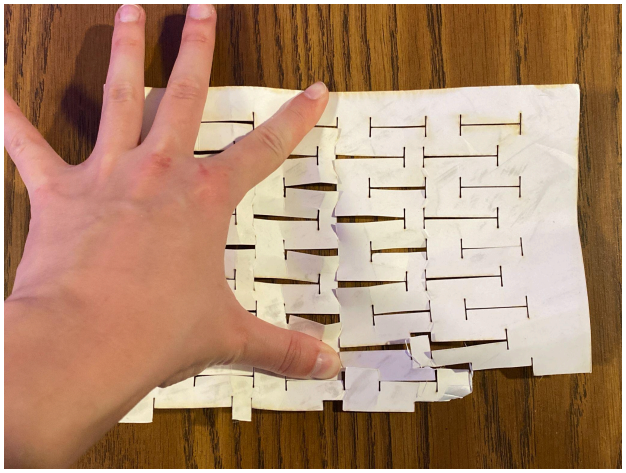
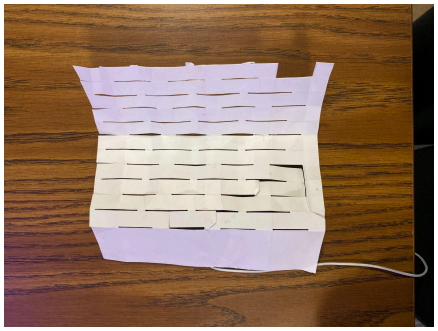
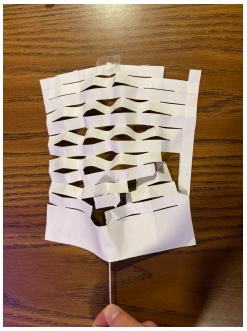
Project 3: Actuating Greenhouse

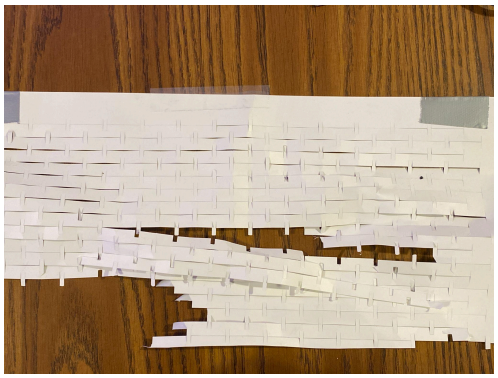
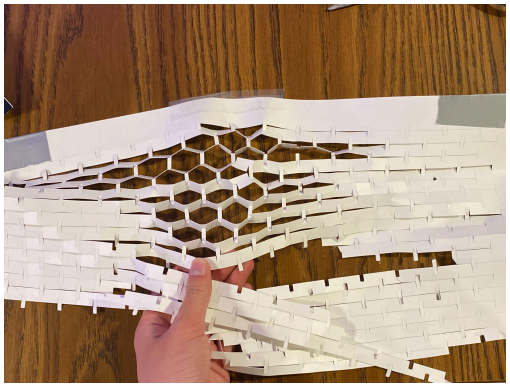
For my third project, I returned to my actuating greenhouse idea from Project 1 - recreate a typical greenhouse.

<u>Kirigami</u>

This time, I wanted to incorporate a roof that allowed for different levels of shade through kirigami. I can't remember what initially inspired me to pursue kirigami, maybe a resource document in the class Google Drive, but it was fun. I replicated, cadded, and tested various designs on Yupo paper. Some images of the testing samples are below.



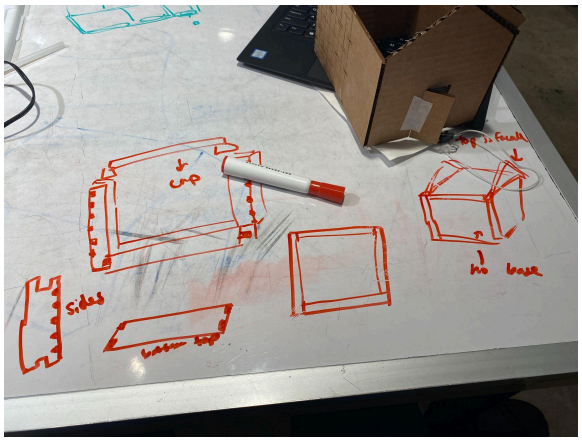



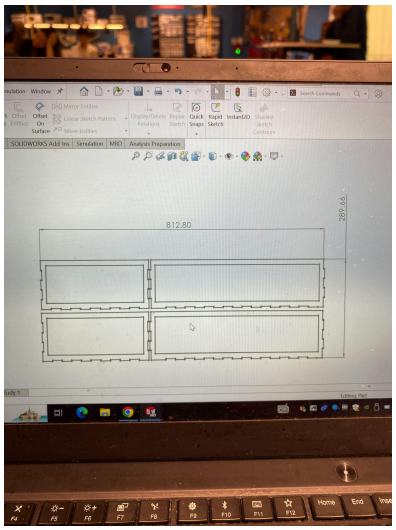
One thing I wished I had done after the fact was be more methodical with my testing.

I didn't keep great documentation of the successes of each design, but was able to reference my physical samples. My testing was not comprehensive in the slightest - tape one side of the paper to a table or have a friend hold the kirigami and pull. There were lots of rips and tears, but I got a tangible understanding of the strengths of certain designs as well as the material properties of Yupo paper (it likes to rip lengthwise). In my final project, the large pieces of Yupo paper and use of Cricut (exacto knife cuts) performed differently than the smaller pieces cut with laser cutting, and I had a lot of issues with tearing. However, the pieces that held resembled what I wanted: little force required to stretch, minimal gaps when unstretched. I was able to get a pretty smooth sliding roof by putting the kirigami on rods and bearings that slid on railings. The video of this is linked in my final presentation: Maya Beach Final Presentation

CAD and Design

I spent a lot of time modeling my frame, and performing repetitive tasks and struggling through Solidworks definitely improved my skills. My goals were to make a frame that was aesthetically pleasing, could have acrylic slide out for cleaning, and made efficient use of materials. Some imagery during this process is included below.


Sides
base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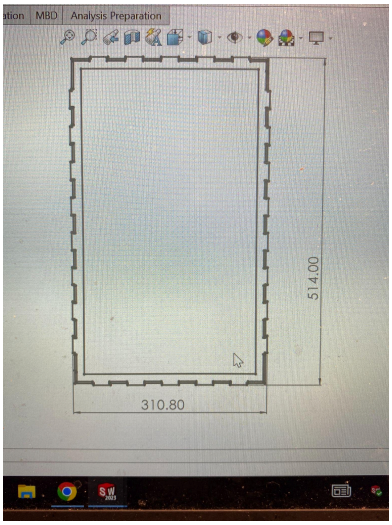
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Analysis Preparation
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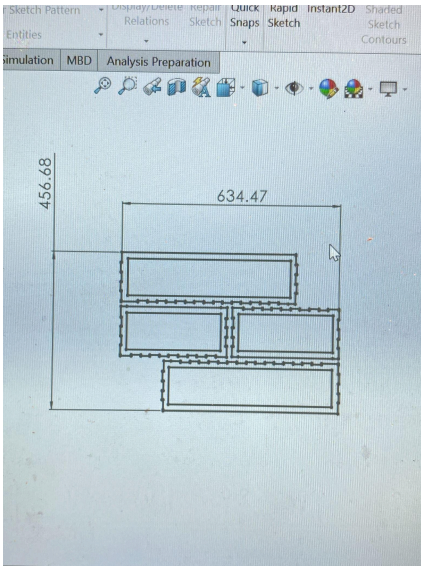
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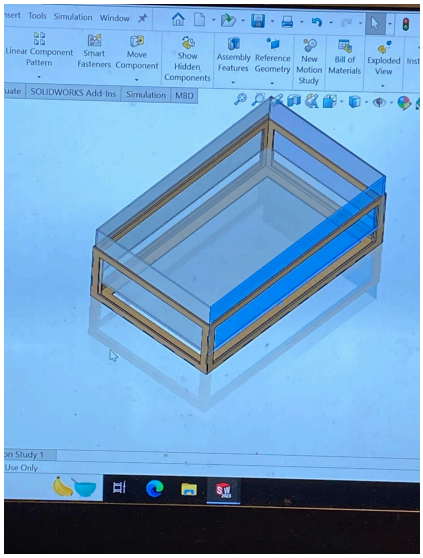
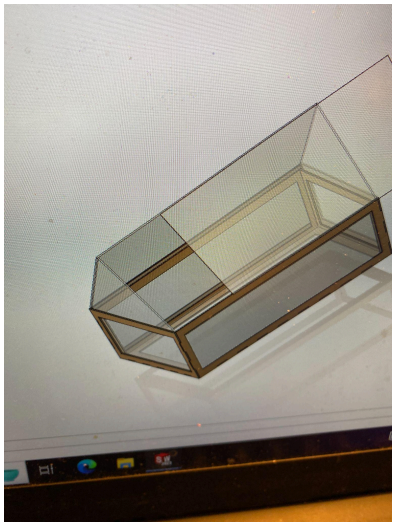
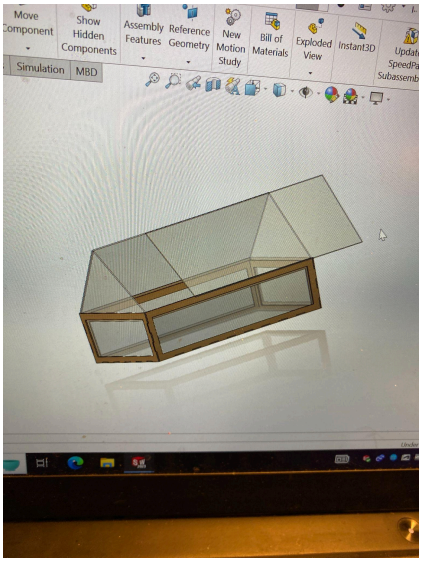
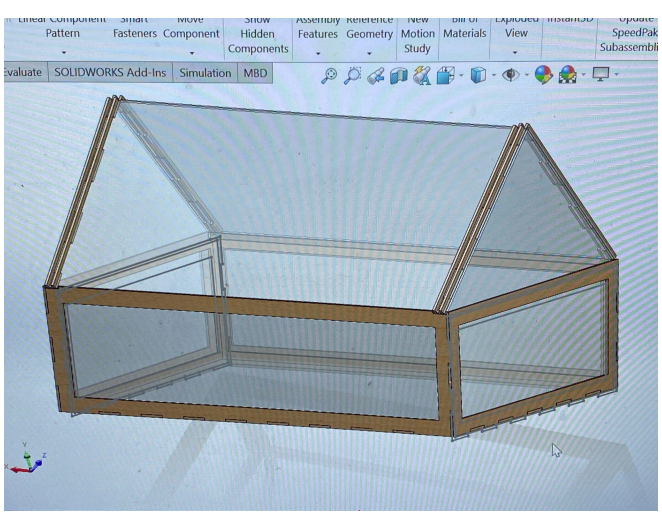
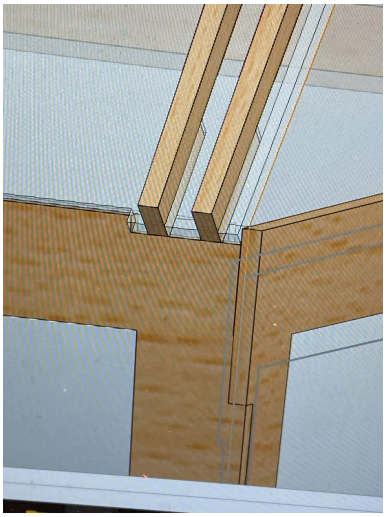
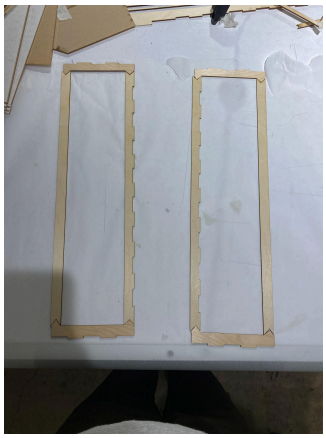
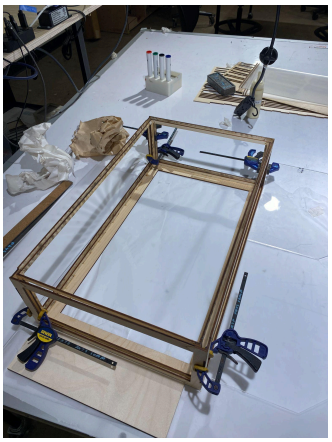






Assembly

I was so engulfed in designing the greenhouse, I forgot to make considerations for how the roof would hinge. I improvised this with lots of tape, velcro, and a metal bar balanced across my two pentagon panels. Assembly went smoothly for the most part, but my pieces needed sanding because I did not account for inconsistencies in the wood. Although difficult to see in the photo below, each of my panels was made up of 4 pieces that had triangle connections which were unique to the pieces they connected to, similar to

a puzzle. The panel on the right does not have the matching pieces, so it is not properly aligned.  

Incorporating the servo mechanism was relatively straightforward, and I decided to use two larger servos to push up the roof at different heights that corresponded with angles. This was activated by a numpad and is pictured in the video in my final presentation.