To: EGR Corporation
From: Michael Jiang, Madison Jaffrey, Sam Savitt
Subject: SportBot
Date: April 15th, 2022

1. Executive Summary

As per the requisition of EGR Corp, our team was tasked with the challenge of creating and designing a 'SportBot' machine that will transfer a sports-ball to another SportBot within our performance group, using sensor-triggering electronics. Our team worked with 4 other performance teams to create a carnival-themed Rube Goldberg-inspired system, which consisted of 5 total electronic SportBot machines (Reference Figures 1 and 2). Each performance team based their SportBot machine off a popular carnival attraction with ours resembling a drop tower (i.e. Tower of Terror). As our SportBot was the first machine of the sequence, our team designed our machine to: accept a ball dropped from the users hand, and initiate the attraction with electronically-triggered sounds and light cues as the ball falls. The end of our drop tower was carefully designed to allow the ball to slow down to the appropriate speed to be easily transferred over to the next SportBot machine: a rollercoaster with an elevator mechanism. At the end of the attraction, our SportBot receives the ball back from performance team 5, completing the circuit. With electronic sensors that trigger screams and flashing lights, our SportBot machine is athletic, colorful, creative, dramatic, and entertaining (Reference Figure 3)

Figure 1: Front View of all 5 SportBots in 4' x 4' square

2. Approach Description and Results

Key Design Decisions and Outcomes:

The critical design criteria/constraints for our SportBot was that our machine must transfer a sports-ball to another SportBot within our performance group, using sensor-triggering electronics. Our SportBot will first accept the ball given from performance group 5, a Ferris Wheel themed SportBot, and pass that ball onto performance group 2, a Roller Coaster themed SportBot. Our device was designed with the goal to accept the ball from group 5 at a height of 18 inches with a funnel device and to also pass the ball over to group 2 with a ramp at a height of 6 inches (Reference Figure 4, 5, 13, and 14). Additionally, The system had to include an arduino component and an electronic component, each performing some action triggered by a unique sensor.

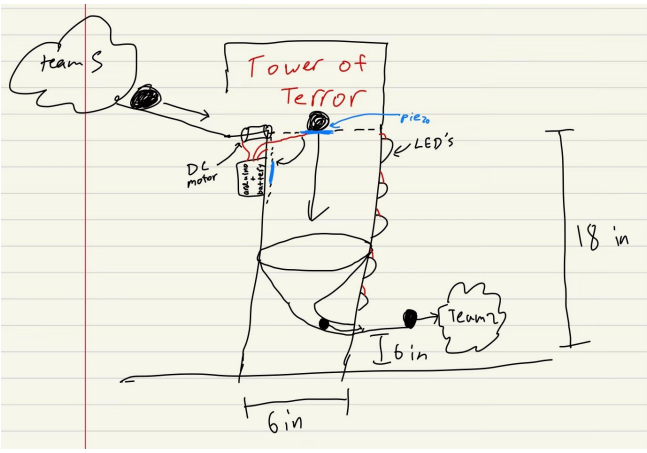

Figure 4: Initial dimensioned sketch of machine (including DC motor eventually excluded)

When meeting with the other performance groups during our brainstorming process, we unanimously voted to use a carnival theme for our Rube Goldberg SportBot system (Reference Figure 6). As a result, our team decided to model our SportBot after a Drop Tower (i.e Tower of Terror). This individual theme was chosen as we believe it to be a design we could feasible create within the given time frame while allowing us creative freedom in integrating electronic components such as LEDs and buzzers to make a more entertaining SportBot.

Some critical assumptions made during the design process were that the golf ball would be dropped by hand into our Drop Tower since our group was the first SportBot machine in the sequence. Additionally, we also needed to make sure that the golf ball would slow down at the bottom of the tower. Group 2 would then include a mechanism in their machine to stop the ball. For the tower design, the casing consists of 4 laser cut wooden platforms held together at the edges by hot glue and masking tape (Reference Figure 7). One implication of this decision was that we could also laser cut a Tower of Terror design onto to the sidewall of the tower, improving the overall aesthetic (Reference Figure 8 and 9).

Figure 8: Tower of terror engraving on box

The front face of the tower included holes for 5 LEDs as well as an opening for the exit of the ball. Inside the tower is a PVC tube which acts as a track for the ball with a joint at the bottom (Reference Figure 10 and 11). This PVC worked well to control the direction and movement of the ball. However, it did not initially slow down the ball enough to be passed on to the next machine, so we experimented with adding different barriers to slow the golf ball down. Eventually, we found that soft pipe cleaners and puff balls were able to slow down the golf ball on the exit ramp enough to instigate a smooth transition to the second SportBot. For electronic components, an ultrasonic sensor was used for the arduino controller to trigger the sequential flashing of the 5 LEDs, and an SPDT switch was used to trigger a scream sound from the buzzer. Both were triggered as the ball initiated its fall and were successfully integrated into the PVC track. The integration of all the electronics together with the PVC can be seen in Figure 12 below.

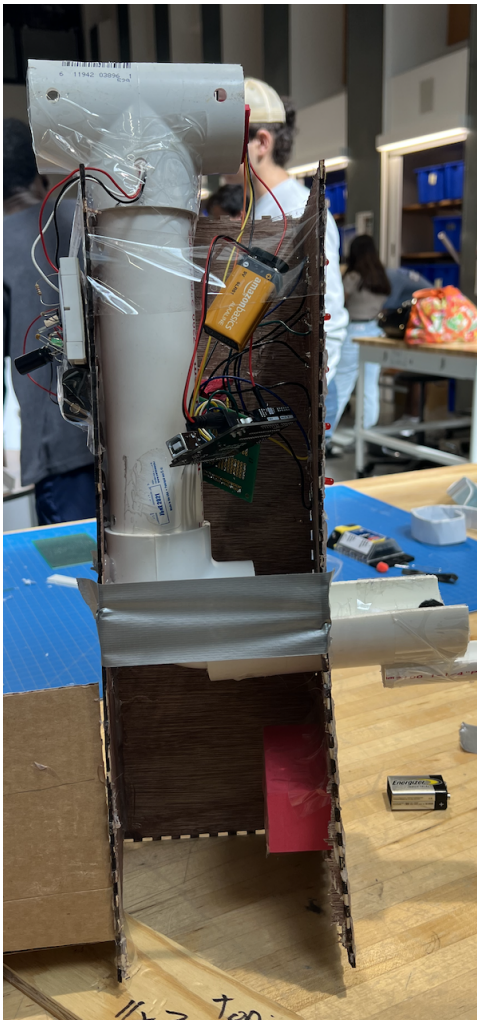

Figure 12: Side view of the Drop Tower showcasing internal components not otherwise visible

SportBot Action Performance Summary:

A key component of our SportBot's design and structure was that our SportBot could continue to perform even if our electronic and arduino components failed to trigger. When the ball drops down the initial input as seen in Figures 3, 4, and 16, it triggers an ultrasonic motion sensor that sets off the arduino component. Immediately after, the ball hits a trigger switch activating the electronic component that's taped to the outside of the box (Reference Figure 15 and 16). The ball will continue to fall down the PVC pipe, which turns 90 degrees at the bottom, and rolls through a cut open pvc pipe filled with puff balls. The puff balls slow down the speed of the golf ball as it leaves our SportBot as it enters an elevator, which serves as the entrance to performance group 2's SportBot. When returning the ball from performance group 5 to our team, we initially planned to collect the ball using a funnel and return the ball back to our initial input. However, we decided against this as many issues occurred when attempting to connect our SportBot with group 5. As a result, we planned to catch the golf ball at the bottom of our Drop Tower with a funnel, designated as our new catch site. However, there were some inconsistencies in our SportBot's performance based on the height and force used on the golf ball at input. Additionally, inconsistencies also occurred due to the unpredictable stability from the Ferris Wheel SportBot when returning the golf ball to our catch site. However, despite these challenges, the golf ball still was able to complete the circuit between all five teams relatively consistently with low error.

Electronics Schematics:

The arduino component consisted of an ultrasonic sensor, 5 LEDs (with 5 corresponding 220 ohm resistors), and an Arduino Uno microcontroller. The complete wiring diagram can be seen in Figure 18. Note that in place of a solderless breadboard seen in the diagram, a fully soldered protoboard was used for the real machine.

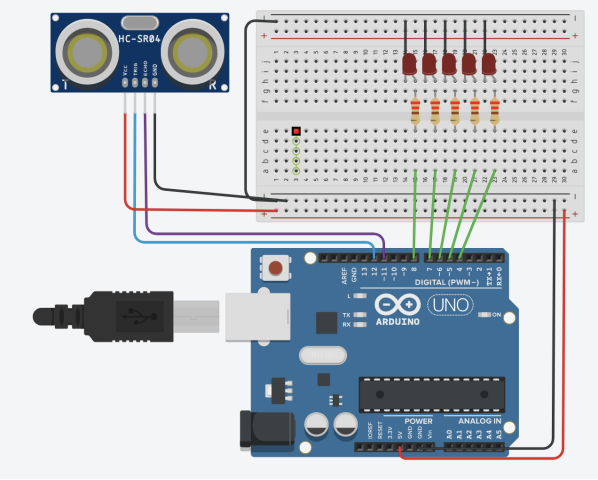

Figure 18: Wiring diagram for arduino component

The electronics component consisted of an arrangement of resistors, capacitors, a transistor, an active buzzer, and a 555 timer used to control the time that the buzzer played a sound. The complete wiring diagram can be seen in Figure 19.

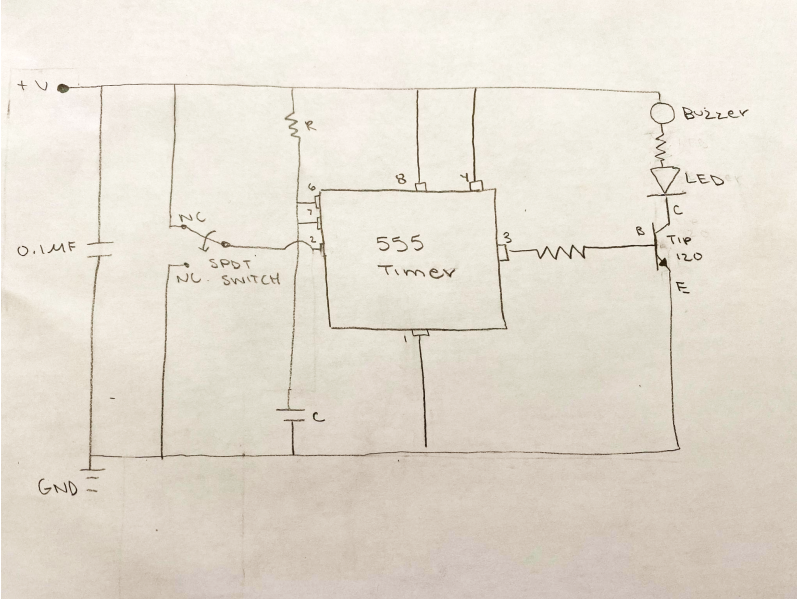

Figure 19: Wiring diagram for electronic component

Personal Contribution Summary:

Team Member	Contributions
Madison	● Found and pieced together inner pvc track with Michael based on group design and initial visualization ● Designed outer box on adobe illustrator ● Laser cut box with Michael ● Assembled box ● Attached pvc components to wooden box ● Worked with group 2 to make sure the transition between the bots was successful ● Attached electrical component to the pvc track through a hole
Michael	● Found and pieced together inner pvc track with Madison based on group design visualization ● Procured wood needed to laser cut ● Laser cut box with Madison ● Helped problem solve initial issues with pvc track and electronics/arduino ● Fixed and finished creating electrical component ● Helped attach electrical component to outside of box
Sam	● Created arduino component ○ Soldered lights and wiring to a protoboard ○ Worked to figure out bugs with arduino until it successfully worked ○ Made the design decision to change sensors when original push button didn't work ● Began and designed electrical component ● Integrated arduino component ● Helped attach electrical component to outside of box ● Helped assemble box

Commentary on Overall Group Interaction:

The success of our SportBot within the greater Carnival SportBot group depended on clear communication and team work both within our team of three and between all 5 SportBot groups. Knowing the challenges of continually coordinating between 5 groups, we sought to address the following major design components in our initial group meeting with other teams.

Key Team-Wide Design Components

- Group Theme
- Individual Bot Theme within larger group theme
- Sensors planned on being used by each team
- Order of bots in the cycle
- Height we were receiving the ball
- Height we were delivering ball

As a group we brainstormed ideas on a white board and worked with other teams to make sure there were no repeats in individual bot themes and a variety of sensors. One area we could have improved on is designating a specific height that each group would be receiving and delivering the ball. We designating a specific height we would be transferring over to group 2, we were able to create a smooth transition between our 2 SportBots. However, we had a slight design change due to not specifying the method we wanted to receive the ball from group 5. While we were able to adjust our design to accommodate group 5, this led to issues between the connection of SportBot 4 and 5. As a result, the unclear communication between the two groups led to SportBot 4 unable to integrate with the rest of the bots. This forced the larger group to create a new last minute SportBot to take group 4's place in the sequence to complete the circuit.

As an individual team, we realized the challenge of meeting as a complete group outside of class. In order to address this challenge, we each took on specific responsibilities, and met in varying combinations of 2, communicating updates with the third member at the end of each work meeting. This allowed us to tackle different design components and integrate them smoothly into our final product. Due to this method of working together, any design changes were made with careful consideration of how it would impact other components and communicated generally ahead of time. In the future, we could stay more organized by documenting our design process in a situation where we can't meet as a full group. However we did a good job effectively communicating and making decisions cohesively as a team overall. We were able to meet at the end of the project as a final team which allowed us to work out design bugs together and communicate with other SportBot teams to integrate our DropTower with the larger group. Overall, as a design team we communicated efficiently, effectively, and clearly with each other as well as with other groups.

3. Conclusion

Our team successfully developed a mechanism that resembles and performs similarly to a Rube Goldberg machine. Our SportBot, or Tower of Terror, senses a ball dropped from a hand at the top of the tower, and initiates electronically-triggered sound and light cues as the ball falls. The end of our drop tower was designed carefully to allow the ball to be easily transferred to the next SportBot machine. With electronic sensors that trigger screams and flashing lights and a beautifully decorated laser cut tower, our SportBot machine is athletic, colorful, creative, dramatic, and entertaining. Though many challenges occurred throughout the entire process, our team is quite proud of the performance of our SportBot, as well of the success of the entire team behind the Rube Goldberg machine.

4. Appendix

Figure 2: Top view of all five SportBots in 4’ x 4’ square

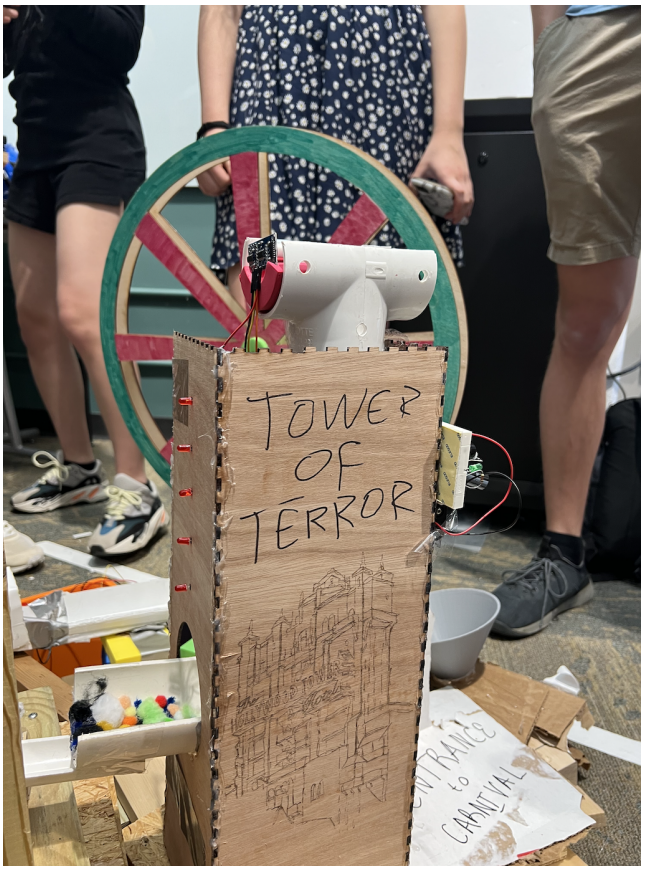

Figure 3: Front view of the final version of the drop tower

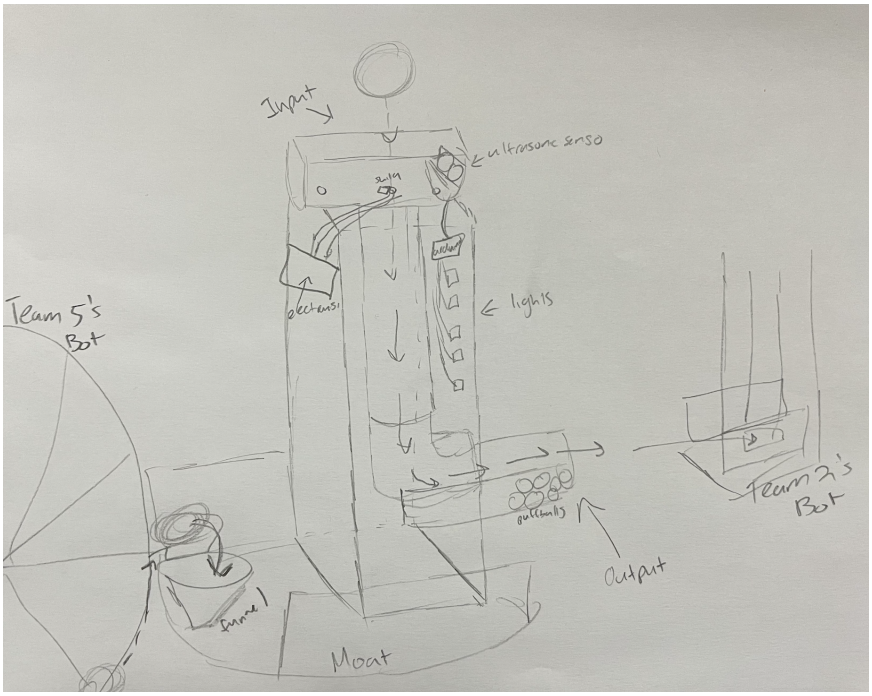

Figure 5: Final Design Schematic based on actualized Sport Bot

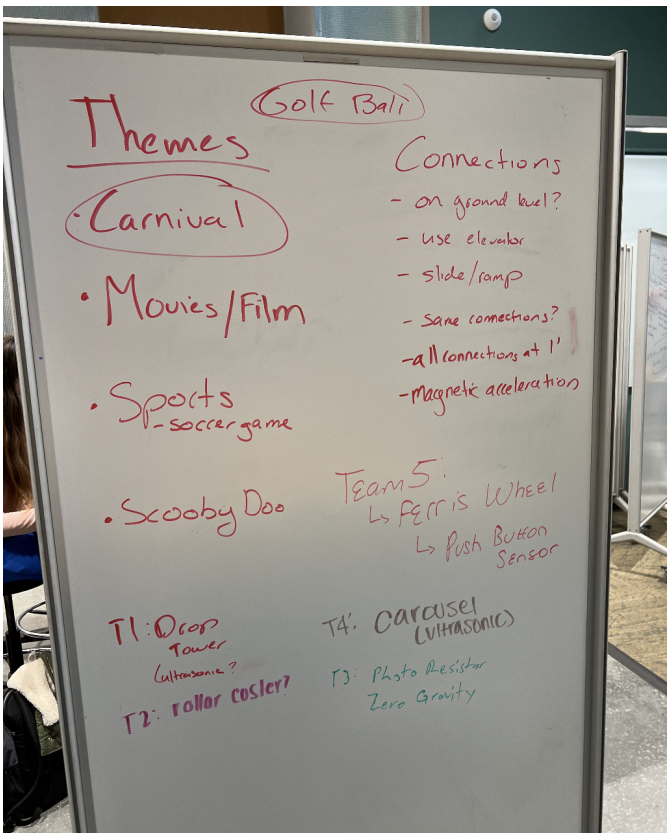

Figure 6: Initial brainstorm by all five teams to decide them and possible connections

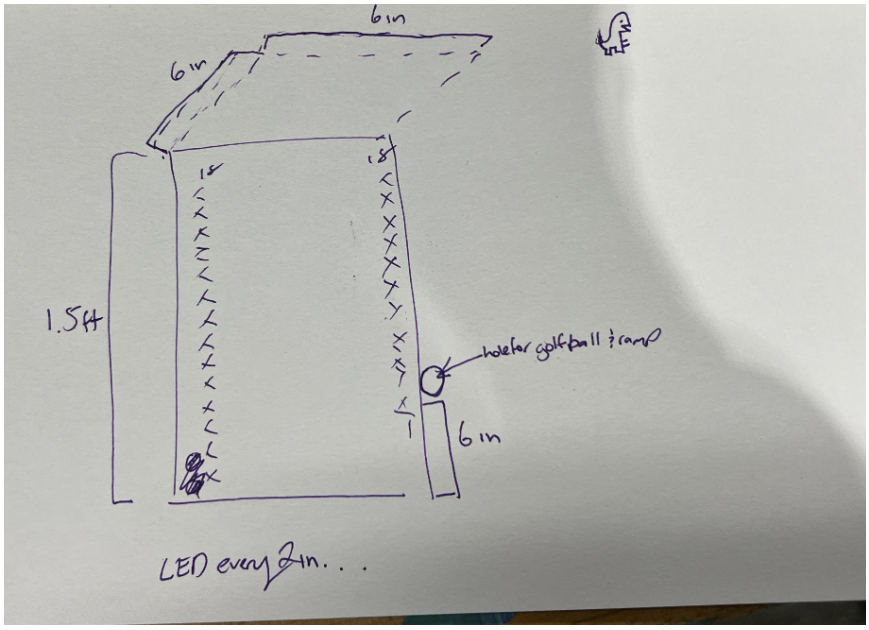

Figure 7: Drawing of brainstormed box with dimensions

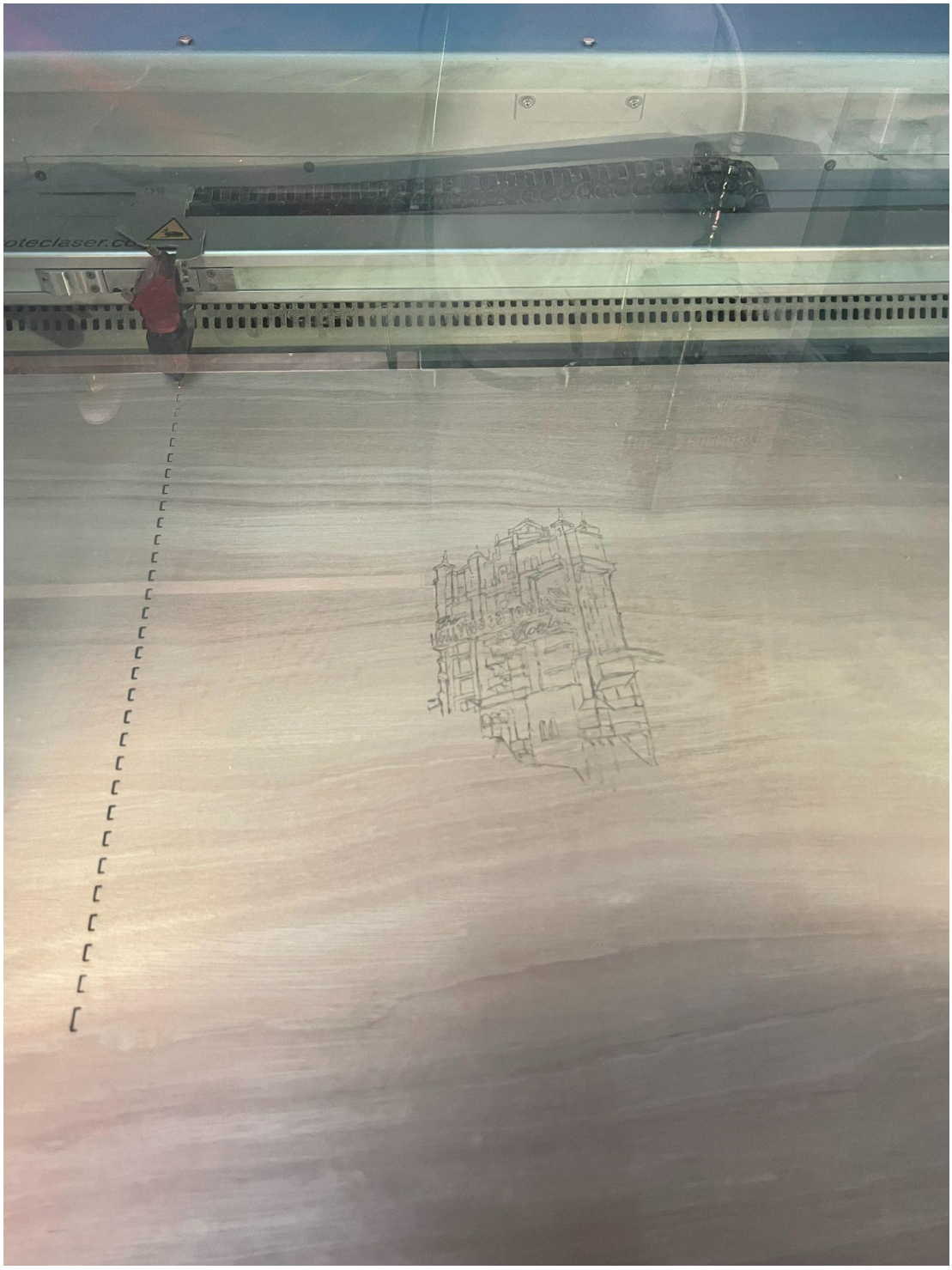

Figure 9: Laser-cutting box for drop tower

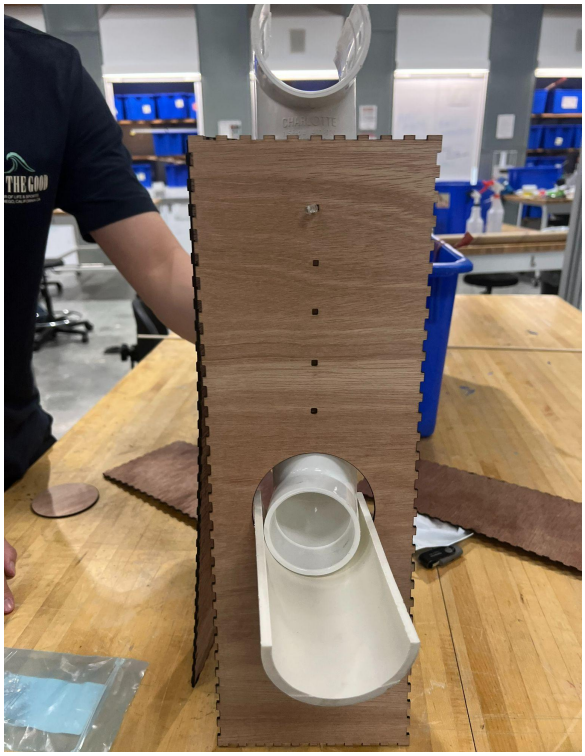

Figure 10: Front view of drop tower with holes for LEDs and exit ramp

Figure 11: Side view of unassembled box

Figure 13: Initial idea for receiving ball from Group 5 (View 1)

Figure 14: Initial idea for receiving ball from Group 5 (View 2)

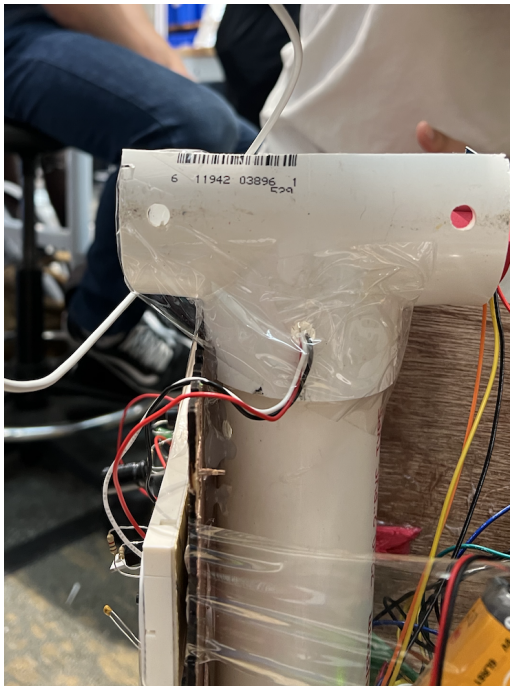

Figure 15: Side view of wires connected to switch threaded through hole in the PVC to attach to the electronics breadboard

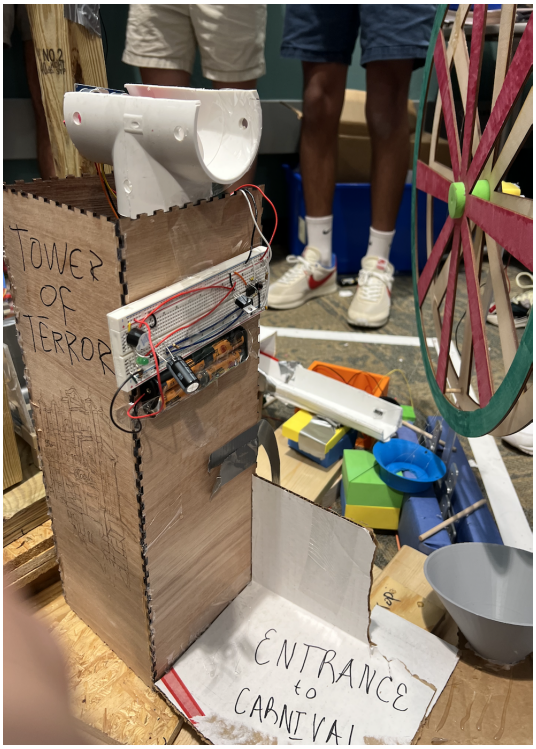

Figure 16: Side view of the final drop tower showing the electronics mounted and the funnel/moat collection at the bottom

Figure 17: Top view of drop tower showing switch and ultrasonic sensor