THOMPSON RIVERS UNIVERSITY

ENGR 1200 - Engineering Design II

Smart Trash Bin

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Date submitted: April 16th, 2021

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- The table of contents should be automatically generated by selecting "References/ Table of Contents". Remember that the table of contents should not have an entry of the "Table of Contents" itself.
- Proofread the text for typing and grammar mistakes.
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1 Executive Summary

- A smart bin would be required for people with disabilities and during this period of Covid-19, the demand for the product would rise. The smart bin cost about $19 since it is a new project we set our goal on producing about 200 of it. It would then be sold for $25 still being one of the **cheapest alternatives** in the market with a profit of about $1,200 to be gained for every 200 smart bins sold.
- Cost of production and distribution are also noted and will cost about $765 each month. This would be done till a contract is made with a bigger company. Which then would be expanded to **1000 smart** bins a year. Although we expect a loss in the first 2 months we will recover by the end of the first quarter of the year.
- During this period customer feedback would be taken to ensure the best product for the user is met but still making reasonable adjustments that would not damage us. The bin is environment friendly and all parts can be reused or recycled.
- We recommend giving the smart bin a trial phase to ensure there will be no problem and changes can be made before the release to the public is done. For future works making the design more **aesthetically pleasing** should be done.

2 Design Problem

2.1 Problem Definition

Our client seeks to create a **fully touchless** operated trash bin. This bin will be able to open without any contact on the bin as well as notify the users if it is at 90% capacity. These features are intended to help people with disabilities in discarding their trash as well as to help limit the spread of Covid-19.

2.2 Design Requirements

2.2.1 Functions

- **Goal of the function:** The main goal of this project is to design a smart that does not require the user to touch it.
- **Action:** The user should walk toward the bin and stay there for a short duration making the bin open. It also displays when the bin is full or not using the LED.
- **Functions:** The main functions of the smart bin are:

    1. It opens when the user stands in front of it.
    2. It closes automatically when the user leaves.
    3. It notifies the user when the bin is 90% filled.

- **Behaviours:** The bin would remain closed until someone stands in front of it making it open and then closes when the person leaves. It also displays how filled the bin is when red 90% of the bin is full else it is green.
- **Structure:** The smart bin is made up: A bin, a LED, 2 Servo motors, 2 Ultrasonic sensors, Microcontroller, Breadboard, Double Male-ended Wires, Male-to-Female-ended Wires, 3 220Ω Resistors, and an external 5V power source.

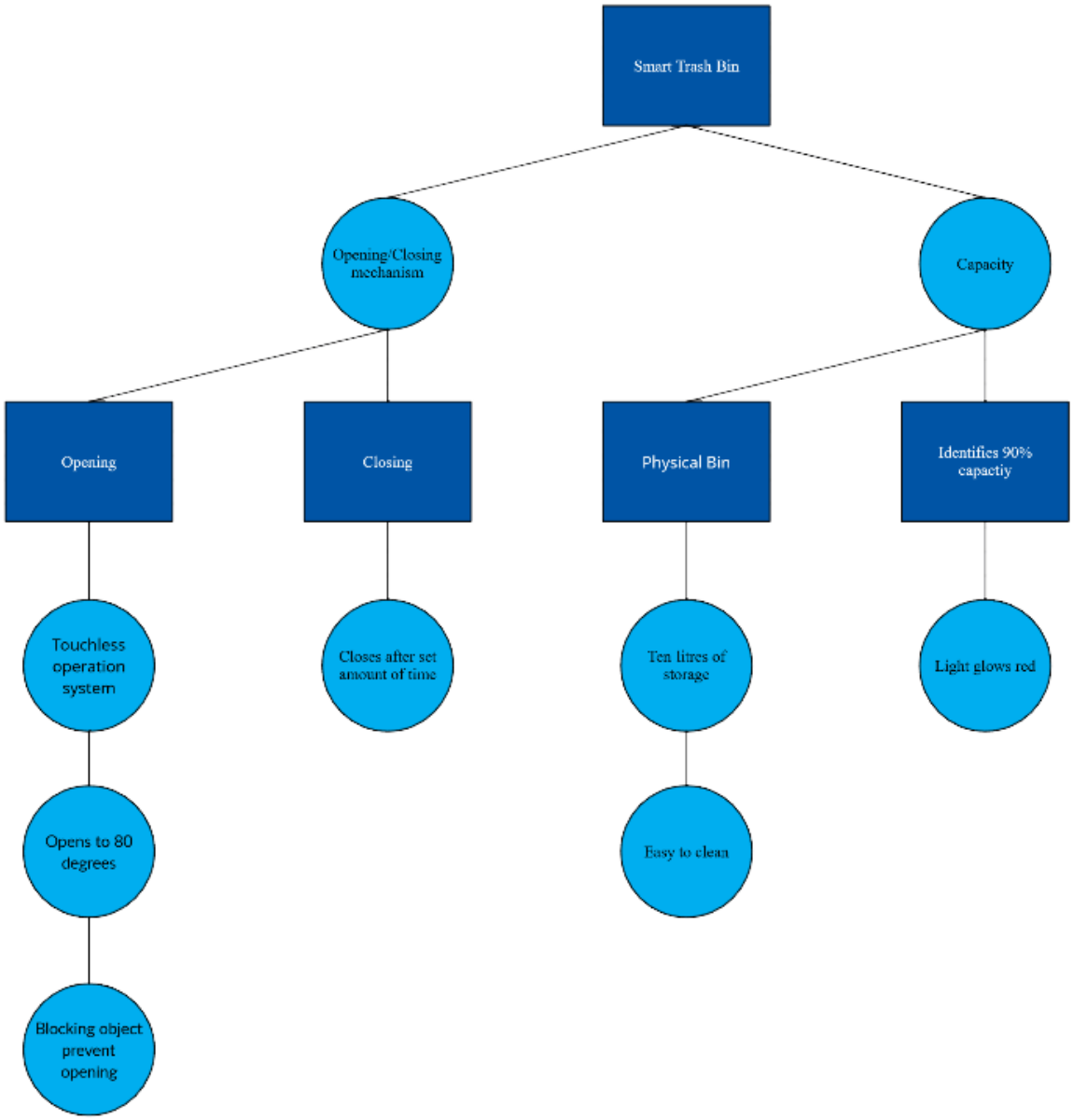

Figure 1. Function Tree

2.2.2 Objectives

- The objective of this project is to design and code a smart bin that will be **touchless**. For our objective, we consider the efficiency of our bin the opening and closing should happen without a user touching it. We ensure it opens up to 87 degrees ensuring the user has a lot of space to put in the garbage. For the cost, we bought a lightweight plastic with a capacity of 10L. We made the bin look appealing to the user by hiding wires.

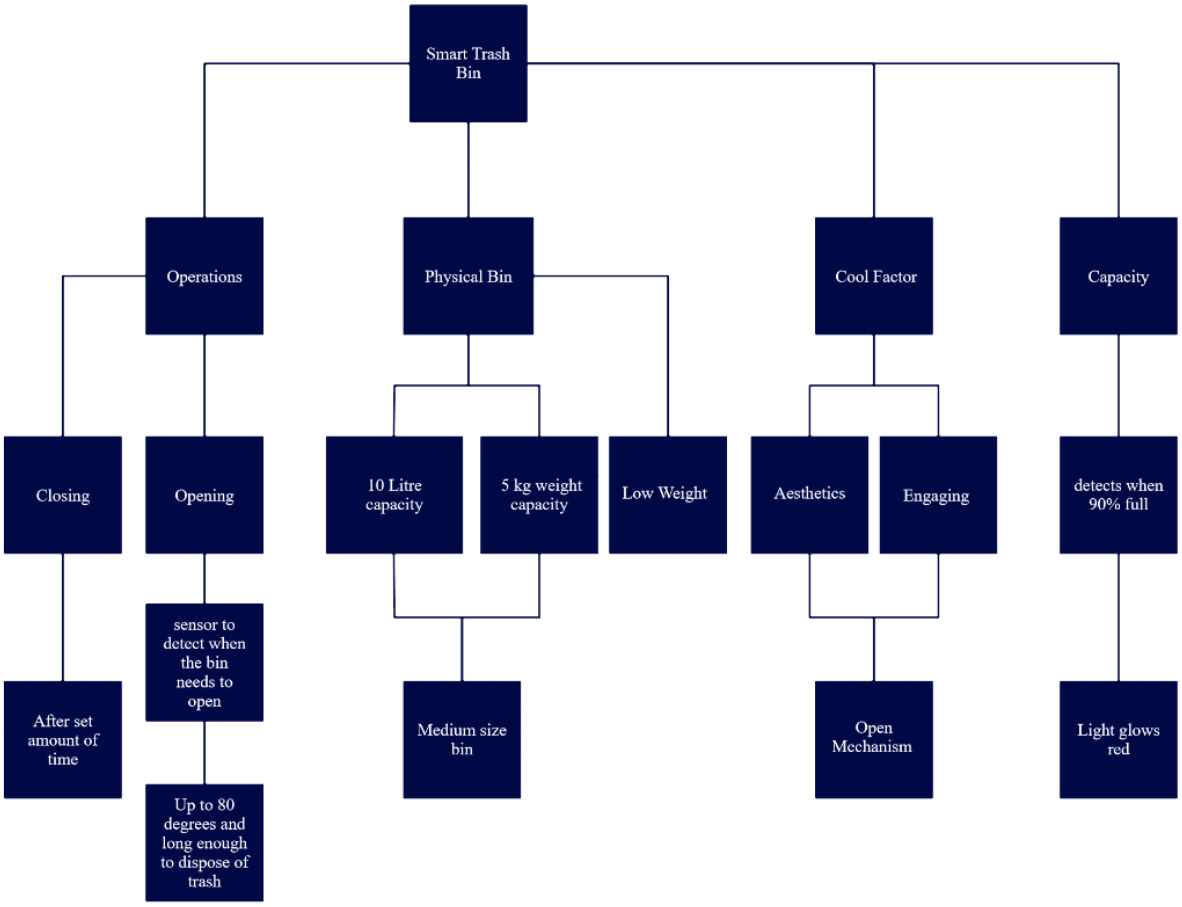

Figure 2. Objective Tree

2.2.3 Constraints

Satisfied:

Project Budget Limit of $20

Trash Bin Volume must be ≥ 10L

Other entities or objects such as pets cannot open bin

It should be easy to clean

It notifies the user when it is 90% filled.

It can carry up to 5kg.

It opens at an angle of 87 degrees.

Not Satisfied:

Weight ≤ 1kg

3 Solution

3.1 Solution 1

The design for the first solution involved a garbage bin that will be standing 5 ft tall with a width and depth of 2ft to make a total volume of 20L with a flat lid set to open for a certain amount of time as long as someone remains a certain distance in front of the bin for **at least 5 seconds**. The bin consists of two servos at the base of the bin which strings will be attached to the servos and the lid of the bin making a pulley system. So, when a user stands in front of it the ultrasonic sensor detects and then the servos will pull the **string opening** the bin. It also reads the amount of waste within the bin using another ultrasonic sensor until it reaches a maximum capacity of 100%. Once full the bin would signal with a red led that it was full.

Pros:

- ➢ Allows for maximum trash to be contained
- ➢ Easy to mass produce since 6 of the sides are the same dimensions (5ft x 2ft x 2ft)
- ➢ No random object or entity passing by will trigger the bin to open
- ➢ More space is left in the bin.

Cons:

- ➢ Not very accessible for wheelchair users
- ➢ May stay open for too long/short of time for the user to discard all waste
- ➢ Takes a while to read someone's there and then opens.
- ➢ May be difficult to swap out trash bags since it’s at max capacity.
- ➢ The strings get stuck to the lid at times.
- ➢ The lid had no closing increments. (closes too fast).

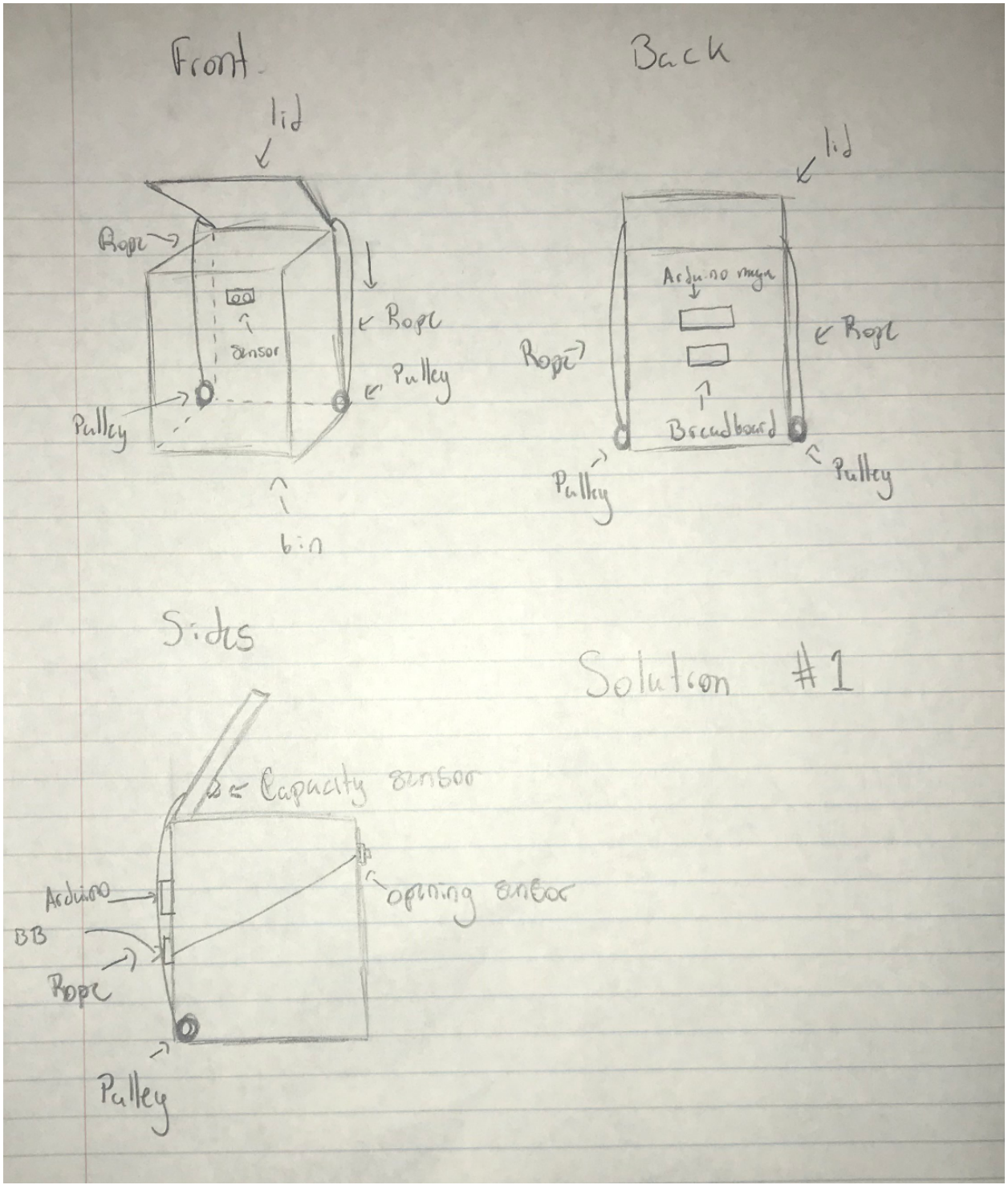

Figure 3. Solution 1 Sketch

3.2 Solution 2

In the second solution, we decided to use different dimensions to accommodate more of the disabled community. The trash bin's height is 4ft with a base of 3 ft and a width of 2 ft to make up a total volume of 24L. It consists of only one servo motor located inside the centre that will raise and close the bin. A motion sensor that **detects motion** in front of the bin. This bin's lid would remain open for as long as a person remained in front of it no matter the length of time. Like the previous one, the bin turned on a red LED to signify that it was full and needed to be swapped out. However, this design capacity sensor only lets the bin get to a maximum fill of 90%.

Pros:

- ➢ User doesn't have to wait for the bin to reopen if more than one load of waste
- ➢ Easy to replace garbage bags.
- ➢ The bin opens instantly for users' quick conveniences.
- ➢ Easily accessible for people with disabilities.
- ➢ It has the lowest cost among all the other solutions.

Cons:

- ➢ Any object moving by the bin will trigger it to open for a brief second
- ➢ Takes slightly more effort to mass-produce (4ft x 3ft x 2ft)
- ➢ Doesn't reach maximum capacity
- ➢ The servo motor could not support the weight of the lead.

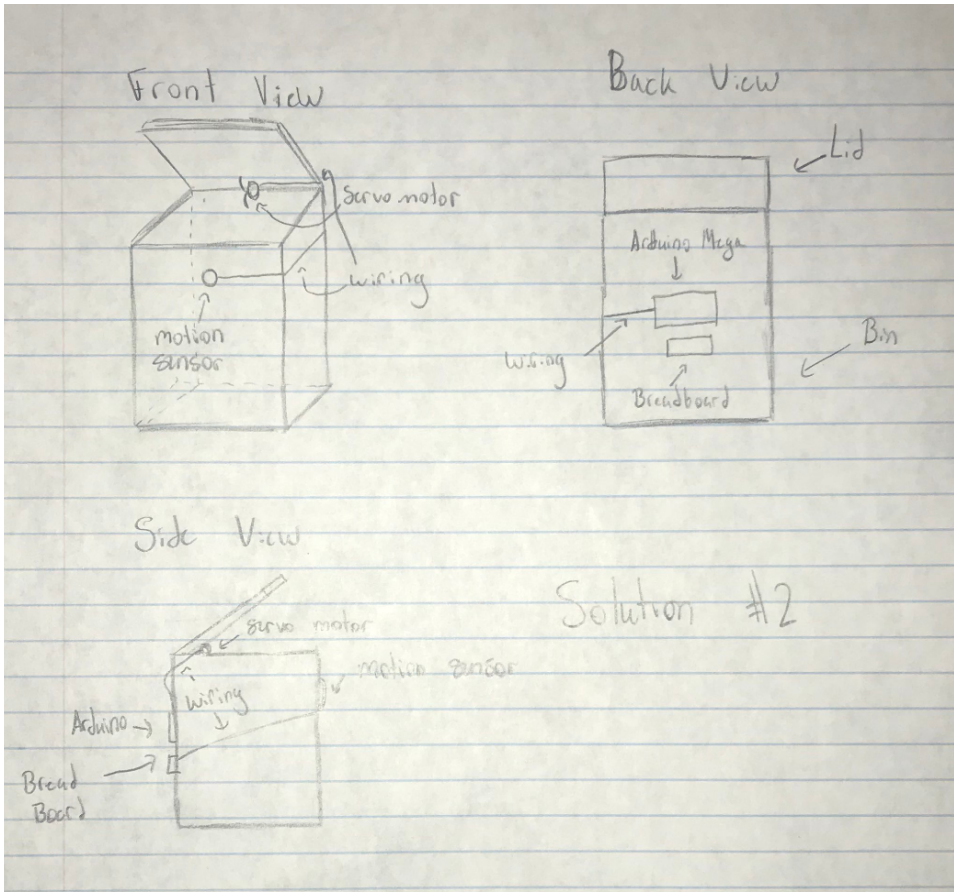

Figure 4. Solution 2 Sketch

3.3 Final Solution

For the final solution, we decided to incorporate the best qualities from the previous two solutions. The final design stands 4 ft tall with a base and width of 3 ft to create a bin with a total volume of 10L to reduce cost and weight. For this solution, **2 servo motors** are located inside the bin and each side would raise and close the lid of the bin. **2 Ultrasonic sensors** one inside that monitors if the bin is 90% filled. The other is located in front of the bin that detects when a user is in front of it for a short duration. **A LED** that displays if the bin is 90% or not. The edges are shaped to ensure the safety of the user. An additional design was for it to be hanged to avoid animals and babies to activate.

Pros:

- ➢ It has a low cost.
- ➢ It is lightweight.
- ➢ It has the best design among all solutions.

Cons:

- ➢ It takes a bit before the lid opens.

➢ Although it meets the constraints the bin could be bigger.

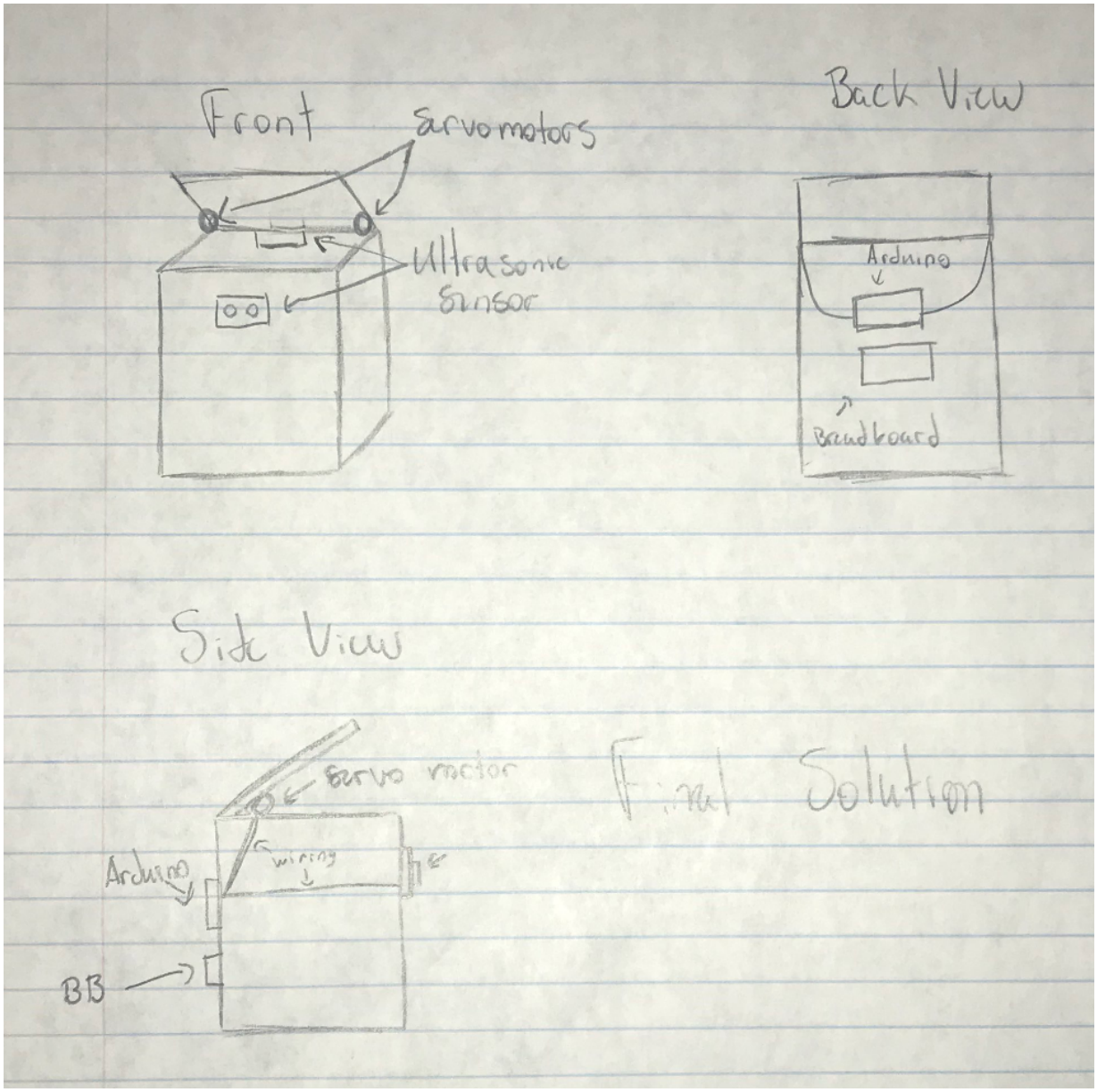

Figure 5. Final Solution Sketch

Design Criteria	Durability	Aesthetics	Cost	Performance	User-friendly	Safety	Sum
Weighing Factor	0.16	0.15	0.14	0.18	0.17	0.20	1.0
Solution 1	6 0.96	5 0.75	7 0.98	5 0.90	6 1.02	8 1.60	6.21
Solution 2	7 1.12	6 0.90	10 1.40	6 1.08	7 1.19	8 1.60	7.29
Final Solution	8 1.28	7 1.05	9 1.26	8 1.44	9 1.53	10 2.00	8.56

Table 1. Weighted Decision Matrix Chart

3.3.1 Components

The purpose of the ultrasonic sensors in our design is to allow for constant measurements to be made. This enables the other components to respond based on the information gathered. The motors used within the project allow for the lid to open and close with no **physical interactions**.

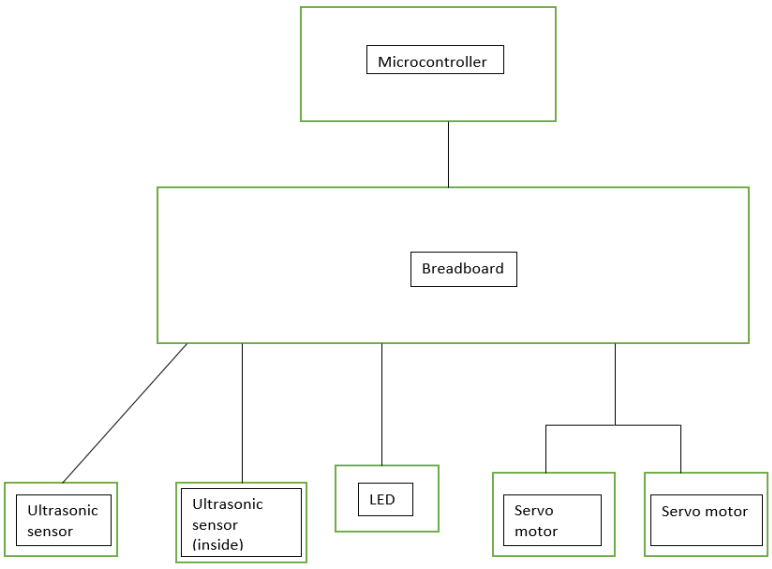

Figure 6. Components Chart

3.3.2 Features

- ➢ Touchless interactions
- ➢ Retractable Lid
- ➢ Can be hung above the ground
- ➢ Notifies when trash levels at maximum fill

For the touchless interactions, our design uses the incorporation of ultrasonic sensors to determine whether an entity is within a certain range from the base of the bin. One is also used to detect whether the waste within the bin is reaching the maximum capacity. When the sensor detects the bin is full, it activates a red LED to signify the users to replace the bag. The lid of our design automatically opens and closes with the use of 2 DC motors connected to prongs which prop up the lid as the motors rotate. The bin can also be hung off the ground by hanging onto the edge of a metal lip located on the back of the bin.

3.3.3 Report on Testing

To ensure all the constraints and requirements of this project were met we set goals and how we would test if our design met them. The table below shows the constraint and what we did to meet the set goals.

Constraints	Goal	How it met the goal
notifies the user when 90% filled	A form display that will notify the user when 90% filled	The bin was marked on 90% so then will calibrate the ultrasonic sensor to detect if the bin is 90% filled or more. The LED would turn red from green if this happens. We tested a lot to ensure it works well.
Opens and Close without the user touching it	The bin should detect if someone is in front of it and then will open.	An ultrasonic sensor was placed in front of it and will detect if a person is in front of it for a short duration. Using 2 servo motors when the ultrasonic sensor detects someone will cause the servos to start moving to an angle of 87 degrees. raising and falling increments were made to prevent a failure of the motors due to stress.

Cost	It should not be more than $20	The bin was made smaller to lower the cost but the material used ensures the bin will have a long time to prevent cost in the future.

Table 2. A table that displays the report on testing

3.3.4 Implementation Requirements

Trash Bin- The smart bin will work as a trash bin and can be used in the kitchen, bedrooms and even offices.

Hung off the ground- An additional feature we add is that the bin can be hung therefore prevent animals from opening it.

emptying and reinstalling garbage bags- The smart bin can be easily cleaned with a trash bin in it. Taking out the trash will be easy and will make the smart bin stay clean.

3.3.5 Environmental, Societal, Safety, and Economic Considerations

A. Life Cycle and Environmental Impact Analysis

For the environmental impact, we made the project environment safe in mind making all parts recyclable or reusable. Parts can easily be refurbished therefore increasing the lifetime of the part.

In this project, we ensure we use parts that can be recycled or reused.

Component	Material	Relative Value, low = 1, high = 10	State of wear	mapping	Decision
Bin	Plastic	2	50% 100% Sacrifice	→ Refurbish → Recycle	Maintain Refurbish Recycle
Ultrasonic sensor	semi-conductor	9	50% 100% Sacrifice	→ Recycle	Maintain Refurbish Recycle
Servo motor	Plastic	5	50% 100% Sacrifice	→ Refurbish → Recycle	Maintain Refurbish Recycle
LED	semi-conductor	6	50% 100% Sacrifice	→ Recycle	Maintain Refurbish Recycle
Microcontroller	semi-conductors	10	50% 100% Sacrifice	→ Recycle	Maintain Refurbish Recycle

Table 3. End of Life Chart

B. Human Factors Analysis - factors related to the users and operators

For the user there are few possible concerns as the only thing that can worry someone is the closing of the bin when replacing the bag, this is an easy fix as placing something between the lid and bin can hold it open

- Open and closing user concerns
- Bin relocation being difficult
- Socially improves COVID scenarios
- Helps disabled people who can't open bins manually
- Overall this bin improves on the social impacts as the bin doesn't need to be physically operated as it is completely touchless making it perfect for disabled people and COVID scenarios. Recommendations for users and operators of our bins are to keep the area in front of the bin clear and maintain the bin; keep it clean and keep the parts working.

C. Safety Analysis -

The safety of any product is the most important aspect of designing a successful project. While making the smart bin we ensure that the safety of the user is met in all cases and parts. To ensure the safety of the user and the people around it.

- All edges are fillet to avoid injuries.
- All parts are secure to prevent damage caused by a fall
- All wires are covered to prevent shock.
- In case of a failure, the bin would not open preventing the user from harm.

3.3.6 Limitations

- The bin weighs more than 5kg.
- The wiring of the bin could be covered to sustain the bin.
- The bin has to always be connected to an external power source.
- The project is a bit bulky because of the microcontroller and breadboard.

4 Team Work

4.1 Meeting 1

Time: March 29, 2021, 5:30 pm to 6:30 pm

Agenda: Design Brainstorming

Team Member	Previous Task	Completion State	Next Task
Raiden Yamaoka	N/A	N/A	Design Brainstorming
Andrei Vivar	N/A	N/A	Design Brainstorming
Jack Ukitetu	N/A	N/A	Design Brainstorming
Matthew Arnold	N/A	N/A	Design Brainstorming

Table 4. Meeting 1 Table

Meeting minutes:

- We have set a goal of brainstorming at least 3 Solutions for our final project
- We have based our designs on existing solutions from the internet

Record of team rule penalty: None

4.2 Meeting 2

Time: March 31, 2021, 6:00 pm to 7:00 pm

Agenda: Code research and material gathering for project

Team Member	Previous Task	Completion State	Next Task
Raiden Yamaoka	Design Brainstorming	10%	Code Research
Andrei Vivar	Design Brainstorming	10%	Material Gathering
Jack Ukitetu	Design Brainstorming	10%	Material Gathering
Matthew Arnold	Design Brainstorming	10%	Code Research

Table 5. Meeting 2 Table

Meeting minutes:

- We have picked our final solution design for our project
- Andrei & Jack have started brainstorming which materials to use
- Raiden & Matt have started searching for existing codes for the Arduino Interface

Record of team rule penalty: None

4.3 Meeting 3

Time: April 3, 2021, 10:00 pm to 11:00 pm

Agenda: Presentation Making and the start of prototype building

Team Member	Previous Task	Completion State	Next Task
Raiden Yamaoka	Code Research	25%	Presentation Making
Andrei Vivar	Material Gathering	25%	Prototype Building
Jack Ukitetu	Material Gathering	25%	Prototype Building
Matthew Arnold	Code Research	25%	Report Making

Table 6. Meeting 3 Table

Meeting minutes:

- Andrei & Jack will start building the Prototype
- Raiden will be making the presentation of the final solution
- Matt will start the report making

Record of team rule penalty: None

4.4 Meeting 4

Time: April 6, 2021, 3:00 pm to 5:00 pm

Agenda: Prototype testing and report making

Team Member	Previous Task	Completion State	Next Task
Raiden Yamaoka	Presentation Making	40%	Report Making
Andrei Vivar	Prototype Building	40%	Prototype Testing
Jack Ukitetu	Prototype Building	40%	Prototype Testing
Matthew Arnold	Report Making	40%	Report Making

Table 7. Meeting 4 Table

Meeting minutes:

- Some conflict with the design for the solution, as the servo motor’s plastic lever, is not long enough to lift the lid.
- A countermeasure was made by adding/ taping sticks to make it longer.

Record of team rule penalty: None

4.5 Meeting 5

Time: April 9, 2021, 4:00 pm to 6:00 pm

Agenda: Project poster making and finishing the prototype

Team Member	Previous Task	Completion State	Next Task
Raiden Yamaoka	Report Making	60%	Poster Making
Andrei Vivar	Prototype Testing	60%	Prototype Finalization
Jack Ukitetu	Prototype Testing	60%	Prototype Finalization
Matthew Arnold	Report Making	60%	Poster Making

Table 8. Meeting 5 Table

Meeting minutes:

- Testing of the prototype
- Making sure that each component was working
- Raiden & Matt will start making the poster for the project

Record of team rule penalty: None

4.6 Meeting 6

Time: April 11, 2021, 6:00 pm to 8:00 pm

Agenda: Report Finalization and video recording of the final prototype

Team Member	Previous Task	Completion State	Next Task
Raiden Yamaoka	Poster Making	80%	Report Finalization
Andrei Vivar	Prototype Finalization	80%	Video Recording
Jack Ukitetu	Prototype Finalization	80%	Video Recording
Matthew Arnold	Poster Making	80%	Report Finalization

Table 9. Meeting 6 Table

Meeting minutes:

- Andrei & Jack will be recording a demo video of the final prototype
- Finalization of the Report is being done by Raiden & Matt

Record of team rule penalty: None

4.7 Meeting 7

Time: April 15, 2021, 7:00 pm to 8:00 pm

Agenda: Project Finalization

Team Member	Previous Task	Completion State	Next Task
Raiden Yamaoka	Report Finalization	100%	Project Finalization
Andrei Vivar	Video Recording	100%	Project Finalization
Jack Ukitetu	Video Recording	100%	Project Finalization
Matthew Arnold	Report Finalization	100%	Project Finalization

Table 10. Meeting 7 Table

Meeting minutes:

- Overview of the entire project, making sure that every member is satisfied with the entire project
- Last-minute changes on the final project if needed
- As a group, all members will evaluate each team member's contribution to the project
- Team members will complete the peer evaluation posted on moodle.

Record of team rule penalty: None.

Scores	**Team member 1**	**Team member 2**	**Team member 3**	**Team member 4**
Name	Raiden Yamaoka	Andrei Vivar	Jack Ukitetu	Matt Arnold
Student ID	T00661480	T00668428	T00647975	T00662228
Total mark	0	0	0	0
Notes and Comments	No rules broken	No rules broken	No rules broken	No rules broken

Table 11. Record of team rule penalty table

5 Project Management

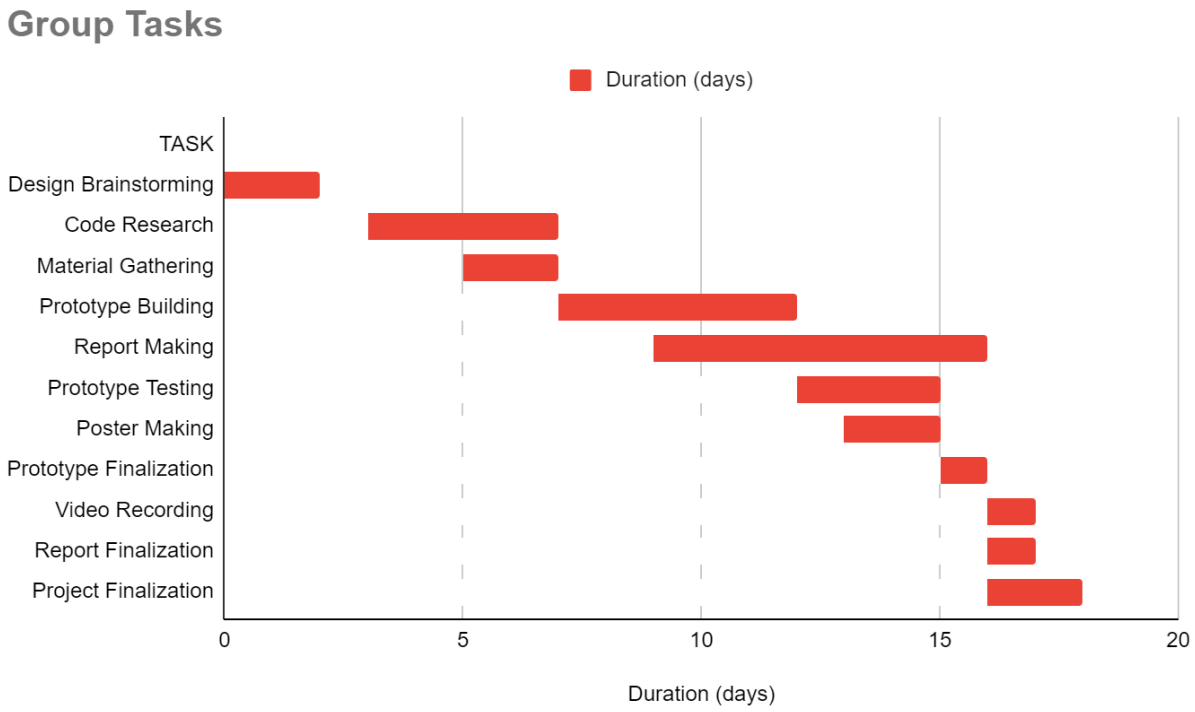

Figure 7. Gantt Chart

For this project, we had **two critical paths** for our tasks: Path 1, which involves Andrei Vivar and Jack Ukitetu, and Path 2, which involves Raiden Yamaoka and Matt Arnold. For **path 1**, the critical path was **Design Brainstorming**, **Material Gathering**, **Prototype Building**, **Prototype Testing**, **Prototype Finalization**, **Video Recording** and **Project Finalization**. Material Gathering was given 3 slack days after Design Brainstorming, as we had to settle on which solution we were going for. Prototype Building, Prototype Testing and Prototype Finalization were not given any additional slack days, as we had to keep working on the final solution and make sure we were satisfied with the result. Video Recording was given 1 additional slack day, while the Project Finalization was not given any slack days. For **path 2**, the critical path was **Design Brainstorming**, **Code Research**, **Report Making**, **Poster Making**, **Report Finalization** and **Project Finalization**. Code Research was given 1 slack day after Design Brainstorming, as we had to make sure which solution we were going for. Report Making was done right after Code Research, resulting in no additional slack days. Poster Making was given 4 additional slack days, as it was not the main priority. Report Finalization was given 1 slack day as we have to make sure everything in the report was good. Project Finalization was not given any slack days, as we have to make sure after all tasks, that the project was complete.

6 Conclusion and Future Work

- As a group, we achieved **multiple big milestones**. We coded a function that operates a **touchless garbage bin** and created a physical working prototype of that bin. Our bin has many features including c**ompletely touchless** operations and a **detection system** to identify when the bin is at ninety percent capacity. We also achieved many cooperative milestones working as a group online. Our final design has many functions that we wanted to include but is still missing some desired features. The features that we have included are; completely touchless opening and closing with a sensor to detect when you want to open it so that no pets can open the bin and so that the bin will only be opened on purpose. The objectives we achieved are based on **operations**, **cost**, **physical bin**, **cool factor** and **capacity**. For operations, **all the main goals were accomplished**. We had opening and closing without any possible harm to the user as well as opening to at least eighty degrees and closing after a certain period with enough given to replace the bag. The bin also has a detection system for when the bin is ninety percent full to prevent wasting any bags. Secondly for cost, we achieved our only goal in regards to cost and made our **product less than twenty dollars** to maintain accessibility for anyone to use at a **cheap price**. Third, the physical bin is only missing one of our goals, that being it weighs more than one kilogram. However, all of our other goals were accomplished as the bin has a weight capacity of more than five kilograms and can carry ten litres without issue. Finally, cool factor, our bin has a **smooth opening and closing system** making it pleasing to watch and also has an added feature of being able to hang making it great for cramped spaces. Although some wires aren't hidden the bin is still not displeasing to look at.
- Our final design is intended to be **used as a kitchen-based bin** therefore more planning and cable management would benefit our product greatly increasing safety. Improvements to the code for next time would be **adding multiple efficiency-based improvements** to keep the bin safer and make it work more efficiently. When it comes to **improving the physical bin the size** could do with a small upgrade. While maintaining the small to medium bin size we think that changing it to fifteen litres for extra additional storage could be very useful. **Lowering the weight** of the bin could also be very beneficial as it will make it easier to move in general.

7 References

Used for inspiration

A. Minhaj, “Arduino Trash-Bot (Auto-Open/Close Trash Bin),” *Arduino Project Hub*, 30-May-2018. [Online]. Available: https://create.arduino.cc/projecthub/ashraf_minhaj/arduino-trash-bot-auto-open-close-trash-bin-fef238. [Accessed: 16-Apr-2021].

Automatic Trash Can - Motion Sensor. YouTube, 2018.