GNG 2101

Design Project User and Product Manual

Accessible Donation Bin

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Table of Contents

Table of Contents ii
List of Figures iii
List of Tables iv
List of Acronyms and Glossary v
1 Introduction 1
2 Overview 1
2.1 Conventions 2
2.2 Cautions & Warnings 2
3 Getting started 3
3.1 Configuration Considerations 3
3.2 User Access Considerations 3
3.3 Accessing/setting-up the System 4
3.4 System Organization & Navigation 7
3.5 Exiting the System 7
4 Using the System 8
4.1 <Given Function/Feature> 8
5 Troubleshooting & Support 12
5.1 Error Messages or Behaviors 12
5.2 Special Considerations 12
5.3 Maintenance 12
5.4 Support 12
6 Product Documentation 14
6.1 <Subsystem 1 of prototype> 15
6.1.1 BOM (Bill of Materials) 15
6.1.2 Equipment list 15
6.1.3 Instructions 16
6.2 Testing & Validation 21
7 Conclusions and Recommendations for Future Work 22
8 Bibliography 23
APPENDICES 24
9 APPENDIX I: Design Files 24

List of Figures

Figure 1: Proper Configuration of MDF Board Frame 4
Figure 2: Image of Motor box 5
Figure 3: Image of Ultrasonic sensor system 5
Figure 4: Electrical Circuitry Set Up 5
Figure 5: Image of the Attached Doors and Handles by Hinges and Screws 6
Figure 6: The Motor Configuration with the Top Chute Using String 6
Figure 7: Image of the Button on the Right Side of the Bin 8
Figure 8: Ultrasonic Sensor Figure 9: The LED Light 9
Figure 10: String Attached to the Motor 10
Figure 11 Figure 12 11
Figure 13: Image of the Notification Box 17
Figure 14: Image of the Connections from the Arduino to the Ultrasonic sensor 17
Figure 15: Image of the LED Light showing the Negative Short Leg 18
Figure 16: Image of the String Glued to the Left Side of the Winch Wheel 18
Figure 17: Image of the Cylinder and How the String Should be Placed on the Cylinder 19
Figure 18: Image of the Motor Cage and the Four Bolts Attaching it to the MDF 19
Figure 19: Image of the Four Bolts from the Outside 19
Figure 20: Image of the Stepper Motor Wires and their Locations 20

List of Tables

Table 1. Acronyms v
Table 2. Glossary v
Table 3. Referenced Documents 24

List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
ADB	Accessible Donation Bin
UPM	User and Product Manual
MDF	Medium-Density Fibreboard
LED	Light-Emitting Diode
GND	Ground
VCC	Power-Supply Pin

Table 2. Glossary

Term	Acronym	Definition
Chute	N/A	The top door of the bin that is used to donate items through

1 Introduction

This User and Product Manual (UPM) provides the information necessary for clients, customers, designers and manufacturers to effectively use the Accessible Donation Bin (ADB) and for prototype documentation. This document contains information about the prototype, how to set it up and use it, troubleshooting, and documentation of the creation process. The intended audience for this document are users, clients, manufacturers, or individuals who aim to learn about the ADB.

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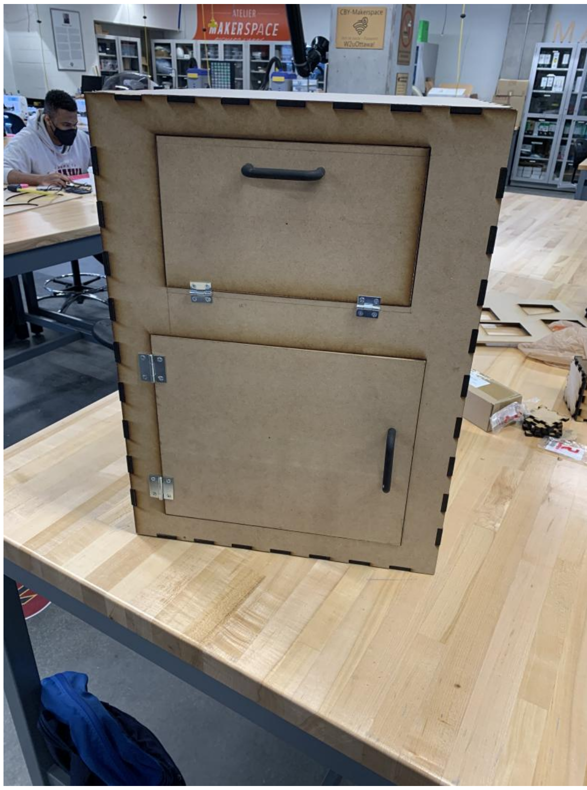
2 Overview

The Accessible Donation Bin is an improved, modernized version of previous donation bin designs. It solves the problems of inaccessibility, item breakage and overfilling. Yet, the design is not over engineered and is still affordable.



Key Features:

- A reachable automatic chute that can open at the press of a button
- Padding within the bin to prevent item breakage
- An ultrasonic sensor to detect and notify user when the bin is full

System Construction and Architecture:

The frame of the bin is built with laser-cut interlocking MDF boards. The doors are set in place with narrow fixed pin hinges. Plastic handles are screwed on to the doors for ease of opening. The inside is lined with bubble wrap for a (temporary) padding solution. The door is controlled by a stepper motor, which is operated through a switch connected by an Arduino Uno microcontroller board. Also within the Arduino circuit is an ultrasonic sensor and LED light that lights up when the sensor detects objects within a specified distance.

2.1 Conventions

Italics: Indicates a statement or consideration of increased importance

2.2 Cautions & Warnings

Warning:

- **General Battery Safety:** The product uses disposable or rechargeable batteries. Improper use of batteries may lead to damage to the product or injury.
- **Moving Parts:** This product has moving parts. Exercise caution when the motor is running, and do not place hands/limbs in between doors.
- **Repair Risk:** Attempting to disassemble/repair the product on your own can lead to damage and/or personal injury. It is recommended that you seek professional assistance for repairs or use caution when doing it on your own.
- **Heavy Object:** This product is heavy. Do not attempt to move it without proper safety measures.

Caution:

- **Follow setup and use guidelines and instructions:** Follow instructions for best results.
- **Proper Installation:** Follow steps or get professional assistance to set up the product.
- **Cleaning:** To clean, remove the padding within the bin and clean either by washing and drying or use a vacuum and detergent
- **Product Usage:** Excessive debris, extreme conditions or prolonged product usage can lead to product damage.

3 Getting started

The ADB is created to be able to be assembled/disassembled by users. The information below provides details on how to assemble, maintain and set up the bin.

3.1 Configuration Considerations

The equipment necessary for configuration/disassembly:

- Phillips & Square head screwdriver
- 9 Volt Battery
- Continuity tester for Arduino

The door hinges can be taken off or replaced by screwing them in/out with the according screwdriver. The box can be put together without requiring tools because of the interlocking sheets. The battery used is a 9 Volt battery, which can be easily replaced. A continuity test can be used to test wired connections if the bin isn't functioning.

3.2 User Access Considerations

- **Owner:** Can assemble, disassemble, and fully access all components of the bin.
- **Donator:** Can use the top chute for donating, but cannot disassemble the bin or use the bottom chute.

3.3 Accessing/setting-up the System

1. Assemble the bin:
    - Connect MDF boards in the proper configuration (Shown in Figure 1)
    - Set up the circuitry (Shown in Figure 2-4)
    - Screw in the hinges and attach doors + handles (Shown in Figure 5)
    - Attach string between top chute and stepper motor (Shown in Figure 6)
2. Perform testing on the functionality of the bin:
    - Check that the switch activates the top chute, and that it behaves as expected.
    - Ensure that the ultrasonic sensor activates the LED light when the bin is filled to the set location.
3. Place the bin in the desired location:
    - An indoor location that is accessible and easy to reach is the recommended location.
4. Maintain the bin over time:
    - Perform weekly/consistent checks to ensure functionality and cleanliness.
    - If necessary, the padding can be replaced, the battery can be changed, and parts can be ordered/swapped

Figure 1: Proper Configuration of MDF Board Frame

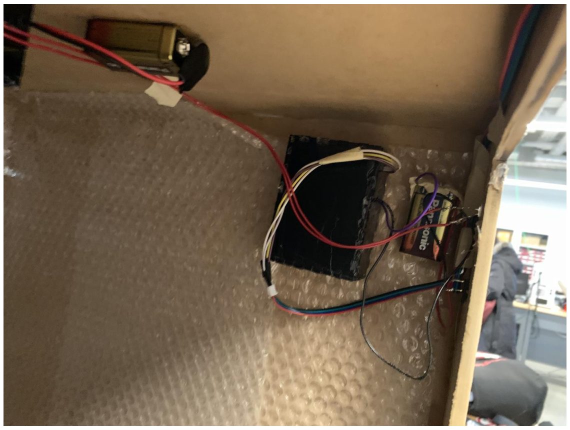


Figure 2: Image of Motor box

Figure 3: Image of Ultrasonic sensor system

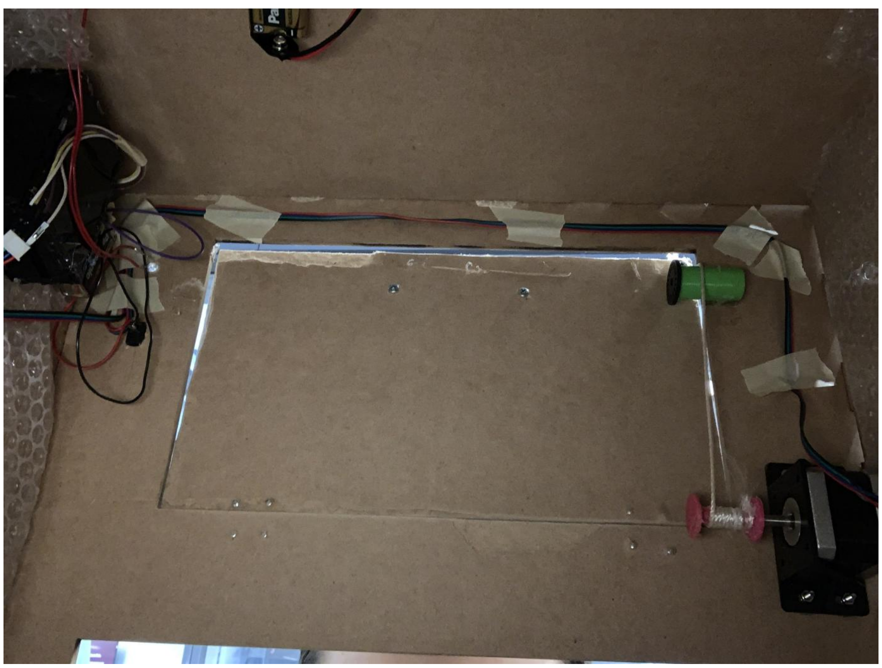


Figure 4: Electrical Circuitry Set Up

Figure 5: Image of the Attached Doors and Handles by Hinges and Screws

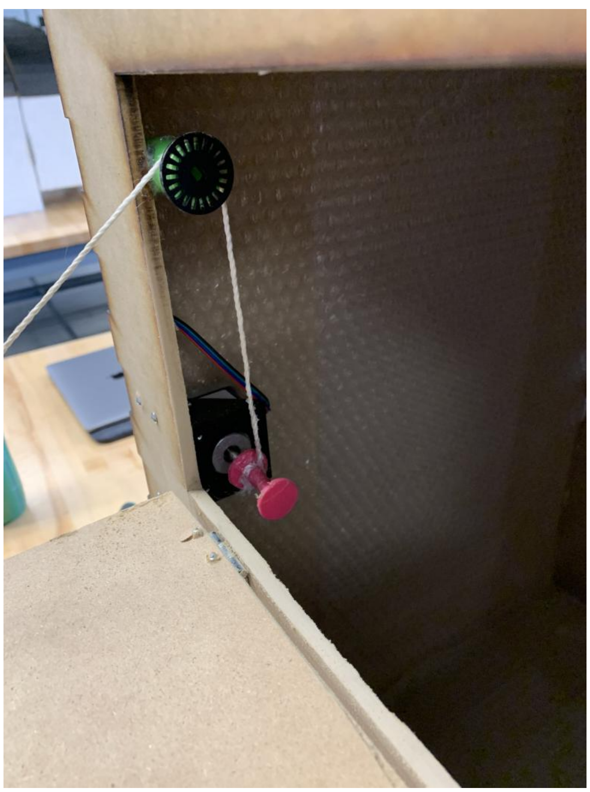


Figure 6: The Motor Configuration with the Top Chute Using String

3.4 System Organization & Navigation

The main component of the design is the frame of the bin. Components within the bin frame include:

Arduino system: Controls the stepper motor and ultrasonic sensor using Arduino code (based on C/C++) and wiring.

Padding: Protects items from breaking within the bin. Is removable from the bin so that it can be cleaned

Components on the outside of the frame include:

LED indicator: Indicates when the bin is filled to a specific capacity (Default distance is 5 cm)

Hinges, doors and handles: Used for opening/closing the bin and protecting the items within

3.5 Exiting the System

To properly turn off the system for storage:

- Disconnect battery from system
- Either:
    - Disassemble the system and store the parts, or:
    - Find an area to keep the bin while it is not in use

4 Using the System

The following sub-sections provide detailed, step-by-step instructions on how to use the various functions or features of the <System Name and/or Acronym>.

For this project, we have two major systems which are the Ultrasonic sensor and the Stepper Motor. The first system is the Ultrasonic sensor. We used the ultrasonic sensor for both the donator as well as the owner to indicate that the bin is full. For them to know that we connected the sensor to an Arduino Uno with LED light. Hence, once the bin is full the ultrasonic sensor will send waves to measure the distance and if the distance reaches the same distance that was put into the program, the light will light up. So, for the donor, that means he/she cannot place items inside the bin. Also, for the owner of the bin, it indicates that the bin must be emptied.

The second system is the stepper motor. To use the motor for opening the chute and closing it, there is a button on the right side of the chute see Figure 7. Once this button is pressed the chute will move down and hold parallel to the floor for 10 seconds. After the 10 seconds pass the chute will go up and d close. Each donor will do the same procedure to open the chute and close it.

Figure 7: Image of the Button on the Right Side of the Bin

4.1 <Given Function/Feature>

- **Ultrasonic sensor**

We connected the sensor, the LED, and the Arduino Uno to the protoboard. We solder all the wires to the protoboard. We also powered the circuit by using an external battery. The ultrasonic feature is to send waves to measure distance. The nicest feature of this type of sensor is that it gives accurate readings as well as, it is easy to program. Arduino Uno contains so many different libraries on the internet.

The sensor was placed on the ceiling of the bin to give an accurate reading as shown in figure 8. The LED light is placed right side of the bin above the black button. It is visible to everyone see figure9.

Figure 8: Ultrasonic Sensor

Figure 9: **The LED Light**

- **Stepper Motor**

We chose this type of motor because it is cheap compared to other motors and easy to program using Arduino UNO. Using this motor, you can change the rotation time as you like. It has enough power to lift up to 6lb. You can get a second motor if you have a heavier item. Also, you can use any type of string and attach it to the motor. We attached a light string and still the motor did the job perfectly see Figure 10. We also 3D printed a part that we placed inside the top left side of the bin so the string can rotate around. That would help the motor to release the string to open the door and pull the string to close the chute.

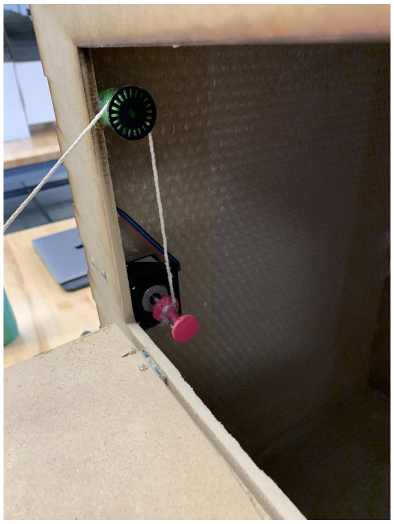
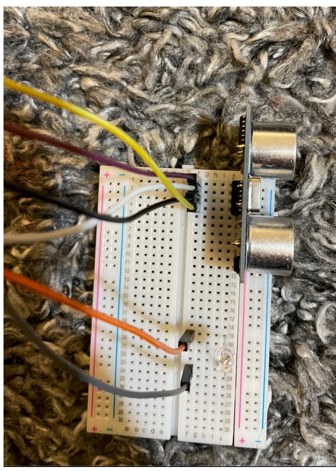


Figure 10: String Attached to the Motor

Circuit

- Get all the required materials, which are, Arduino Uno, jumper wires, and an external battery.
- Place the sensor on the breadboard, as shown on figure 11.
- Place the LED light on the breadboard, as shown on figure 12.
- Connect the VIN pin with the positive side of the LED and connect the ground pin with the negative side, as demonstrated in figure 11.
- Connect the other 4 wires, the one the sensor (GND) with pin (7) and the other one Echo with pin (11). The third one is Trig with pin (10). Lastly, The VCC with pin (5V).



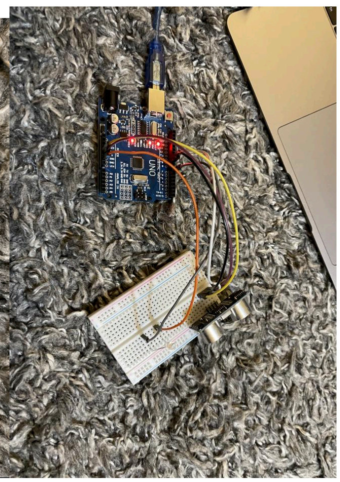


Figure 11 **Figure 12**

Arduino

- Arduino code Software.
- Create function to read from pins where the Ultrasonic and the motor are connected
- Create function to send pin state of the sensor as well as the button to the Arduino Uno.

5 Troubleshooting & Support

For the accessible donation bin, the most common problems that might occur are breakage or malfunctioning of parts, disconnection or damaging of wires, or failure of electric connections

5.1 Error Messages or Behaviors

- In the case of one or more components don't work, or the system does not turn on, check that all parts are connected and that the wires are soldered properly and don't need changing
- If any of the parts are broken or significantly damaged, purchase of new parts and replacing the old parts might be needed
- If the door gets stuck or is not in the right position, it might need to be manually repositioned by accessing it through the second door below

5.2 Special Considerations

- Always make sure the power is turned off before performing maintenance, doing any repairs, or replacing parts
- Avoid placing any heavy items or large amounts of liquids as it may cause significant damage to the bin
- After using the bin, make sure the door is back to its original position before switching off
- The bin should always be switched off when not in use to avoid draining the battery

5.3 Maintenance

- Preform consistent checks to make sure the parts are clean from any dirt or debris and keep away from any extreme conditions or high temperatures
- Inside padding must be cleaned regularly and changed whenever needed
- Depending on the usage, or after a long period of abandoning the batteries should be checked and replaced if required.
- Any parts screwed in or glued should be checked and tightened or glued again if needed

5.4 Support

In the case of any issues arising, emergency help, or any inquiries contact any of the members listed below, clearly describing what the problem is to us and we will try to provide the required assistance.

Paul Bawor: pbawo047@uottawa.ca

Fares Helal: fhela021@uottawa.ca

6 Product Documentation

The final prototype was built over two weeks and can be separated into three main categories. Firstly, the structure of the box was made, which was then followed by the light sensor and finally the motor. The three subsections can further be classified into mechanical, electrical and software but were worked on simultaneously by multiple team members

The prototype began with a frame of six MDF boards that are 18"x24"x1/4" in size. We first wanted to construct the structure out of metal so that it may be durable and robust. The metal was not feasible in cost and would cause difficulty in the manufacturing process. Our group then decided used MDF boards that are strong and would be able to be cut by the laser cutter. We first assembled the entire box before working on electronics. There are many ways to construct a box. Our group decided to use MakerCase, which creates a finger joint design cut out by a laser cutter. Other options such as Solidworks sketches and power tools would not be time efficient and would not provide the strength required. When the box is complete, the boards are not secured until the electronic components are complete.

The creation of the notification device consists of a mechanical and electronic component. The mechanical subsystem consists of a box made from 1/8" acrylic. The box is 2"x2.5"x4" in volume and uses MakerCase and the laser cutter. Using Solidworks, two circles and a square are cut out for the sensor and the wires, respectively. Next, the electronic component consists of the ultrasonic sensor, an Arduino and four females to male jumper cables. The female-to-male jumper cables provide an easy connection between the sensor and Arduino. The use of soldering is not required, making the process simple. There are multiple ways to supply power to the Arduino. Using a 9 V battery to a 2.1 mm jack connection, a supply of electricity is achieved. Arduino is useful for its vast array of public domains and simple design. Our group downloads the newping.h domain, to create a code that can measure distances. The code is available online with only a few changes based on the distance the LED bulb should light up. The LED bulb is connected to the Arduino using long wires and soldered for security. As the electronic system is complete, it mates with the acrylic box. The entire notification system is screwed to the top MDF board.

The last component of the donation bin is the motor. Our initial design for the project included a ramp around the sides and rear of the donation bin, but this was not feasible. Our group then decided to make a chute that opens automatically using a button. Our group overcame difficulties in providing enough power and writing proficient code. Our first option was to use the DC motors included in the chariot kit. The DC motor did not have enough torque making it unable to spin the winch to lift the chute. Our group then used a larger stepper motor with the necessary power, as shown by the calculations below. To create a wheel that attaches to the stepper motor and spools the thread. A wheel designed on SolidWorks with dimensions that lock onto the motor axle. The use of solid works is beneficial as this part can be recreated to different sizes to increase or decrease the speed of the chute. During the setup of the electrical components, our team faced difficulty making a proper connection. The stepper motor has four wires that go into four specific places on the motor shield. Our group researched where the wire should attach to create a circuit. There is little information on an Arduino motor shield with the stepper motor, as most individuals use a different system. Once the connection is made, our group simultaneously works on how to create a code. The automatic donation bin rotates down and stops once it is parallel to the ground.

After waiting in the parallel position for 15 seconds, the chute returns to its initial position. The last part of the motor component is the attachment to the box and connecting the power source.

6.1 <Subsystem 1 of prototype>

6.1.1 BOM (Bill of Materials)

Part name	Description	Quantity	Unit Price ($CAD)	Total Price ($CAD)	Already have
MDF Boards	Link	6	$4.00	$24.00	X
Acrylic Board	Link	1	$13.00	$13.00	X
Ultrasonic Sensor	Included with Arduino kit	1	N/A	N/A	✓
Arduino + Breadboard	Included with Arduino kit	1	N/A	N/A	✓
Jumper Cables	Included with Arduino kit	~30	N/A	N/A	✓
Nails	Link	1	$7.49	$7.49	X
LED Light	Included with Arduino kit	1	N/A	N/A	✓
Small Hinge	Link	1	$3.5	$3.5	X
Large Hinge	Link	1	$4.77	$4.77	X
Stepper Motor	Link	1	$22.99	$22.99	X
Bubble wrap	Link	1	$10.99	$7.99	X
Handle	Link	2	$1.62	$3.24	X
Screws	Link	1	$2.97	$2.97	X
Batteries	Link	2	$1.98	$3.96	
			Subtotal:	**$90.85**	
			Total:	**$102.66**	

6.1.2 Equipment list

- Laser Cutter
- Soldering Iron
- Solder
- Drill
- Drill Bits
- 3D Printer
- Sandpaper
- Phillips #1&2 Screwdriver
- Hammer

- Computer
- Solidworks Software
- Inkscape Software
- Ultimaker Cura Software
- Arduino Software
- USB
- Printer Cable
- Cable Cutters

6.1.3 Instructions

The final prototype can be built over one week and can be separated into three main categories. First, the structure of the box, followed by the light sensor and finally, a stepper motor. The three subsections can further be classified into mechanical, electrical and software components.

1. Begin by downloading all the files on the MakerRepo page onto a USB. The MakerRepo link is listed in appendix 1.
2. Plug the USB into the laser cutter computer and find the document called "Right Side" to print. Use the settings on the laser printer to find the correct speed, power, and frequency.
3. Repeat steps 1-3 for all the side of the MDF box and the two other boxes which use the acrylic board. The dimensions for the box are a length of 7 cm, a width of 6 cm and a depth of 3 cm.
4. To finalize the acrylic boxes, cut out two circles and two squares. The laser cutout file is on the MakerRepo and should be on the USB. Follow steps 3 to cut the file "Cutout for Ultrasonic Sensor" on the large acrylic piece and the "two squares" on the small cutout. The square hole must be cut on both boxes on the smallest piece so that each box can have wires connecting the Arduino.
5. Next, bring together all the cutout pieces to create the box structure.

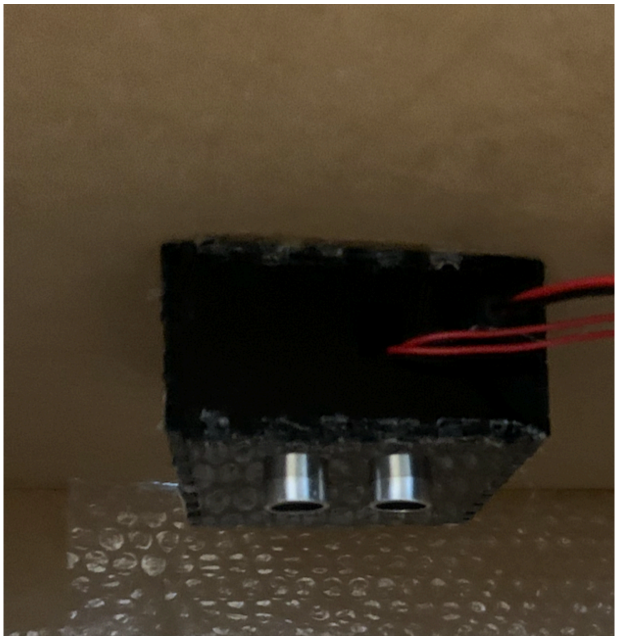


Figure 13: Image of the Notification Box

6 To make the notification system, connect the wires from the ultrasonic to the Arduino shown in the figure below.

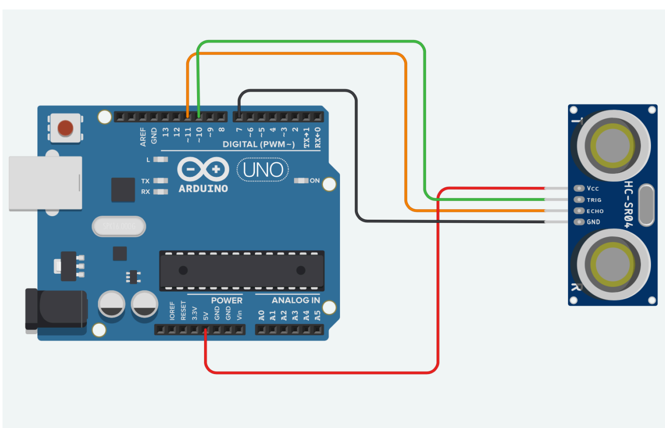


Figure 14: Image of the Connections from the Arduino to the Ultrasonic sensor

7 Solder the LED light to the two long pieces of wire and attach it to the Arduino shown in the image below. Make sure that the black wire is soldered to the smaller leg of the LED as this is the negative side.

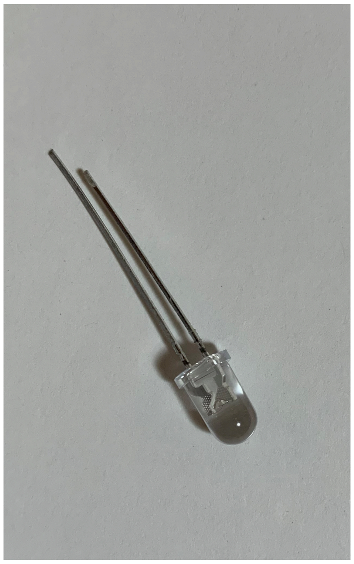


Figure 15: Image of the LED Light showing the Negative Short Leg

8 Open the Stepper Motor code and upload it to the Arduino. Connect the power from the battery to the Arduino using the 3.1mm cable.
9 To create the winch wheel, 3D print the Solidworks file. Use the Ultimaker Cura printing software and open the STL file. Print the wheel using supports.
10 Once the wheel is complete make sure to sand the entire piece to make it smooth and remove the excess material in the center hole.
11 Repeat steps 10 and 11 for cylinder file listed in the USB.
12 Attach the Winch Wheel onto the axle by placing it into the hole. The fit should be tight, and the use of glue is not required.
13 Next, glue one end of a 20 cm string to the far left sight of the wheel.

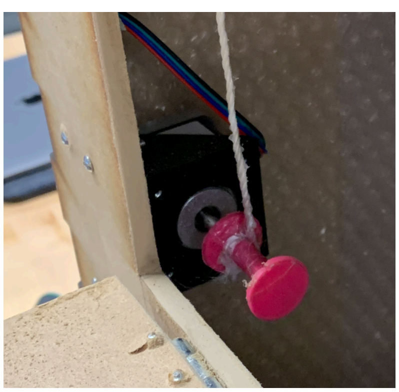


Figure 16: Image of the String Glued to the Left Side of the Winch Wheel

14 Glue the printed cylinder 5cm from the top of the box. Place the cylinder on the left side of the chute opening with the cylinder over the edge. Use the image below as a reference.

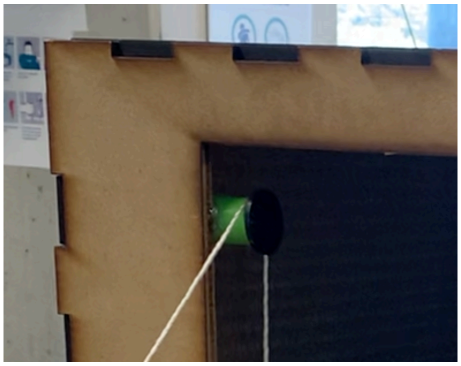


Figure 17: Image of the Cylinder and How the String Should be Placed on the Cylinder

15 To attach the motor to the bin, use the motor holder and the four bolts which came with the package. Place the cage so that the axle is level with the bottom edge of the chute. Also, have the left ridge of the 3D printed wheel inline with the left edge of the chute opening. Mark the four holes in the motor cage with a pencil.

16 Drill the four holes from the inside and attach the cage to the bin using the four bolts. Secure the bolts with the nuts and tighten them with an Allen key.

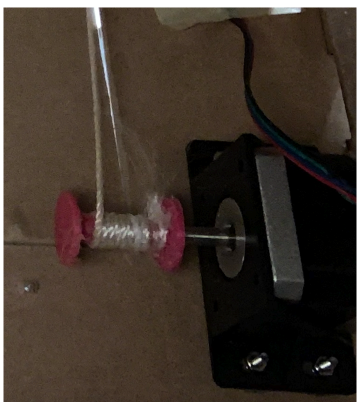


Figure 18: Image of the Motor Cage and the Four Bolts Attaching it to the MDF

Figure 19: Image of the Four Bolts from the Outside

17 Remove the motor from the cage and begin working on all the connections. First, connect the four jumper wires to the stepper motor shown below. Reading the ports from top to bottom with the light on the bottom half, attach the black wire to the 3rd port, the green wire to the second port, the blue wire to the fourth port and the red wire to the first port.

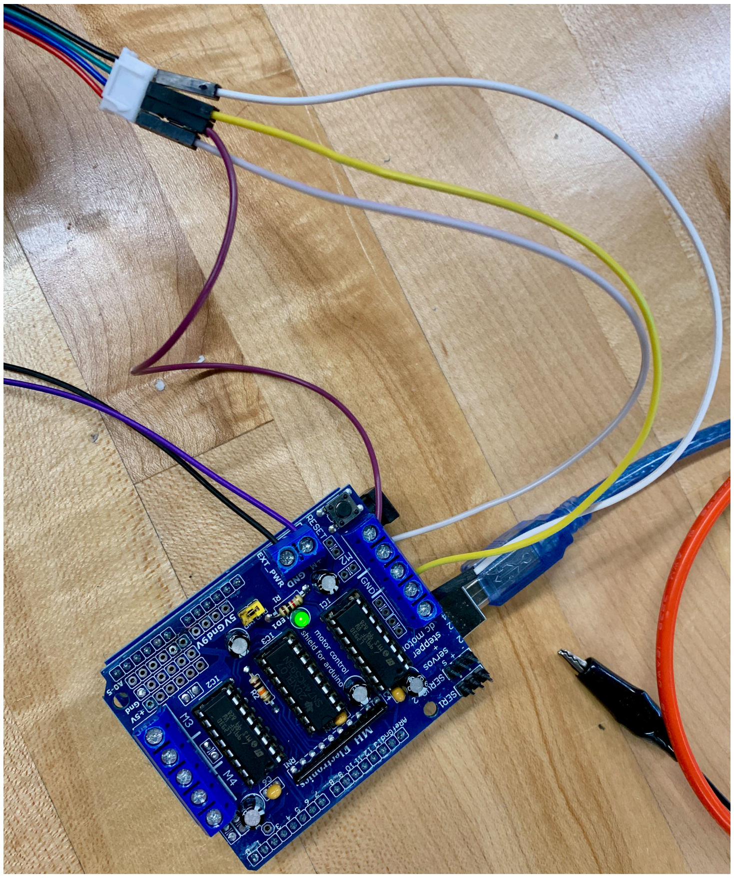


Figure 20: Image of the Stepper Motor Wires and their Locations

18 Upload the motor code listed in the document to the Arduino.
19 To power, the Arduino and motor connect the black wire to the negative port and attach the red wire to the positive port.
20 To create a switch for the Arduino, solder the red wire from the Arduino onto the switch leg. Attach another positive red wire to the other side of the switch leg, which will connect to the battery.
21 Next, use electrical tape to secure the black wire to the negative side of the battery and attach the red wire to the positive port.
22 To secure the motor system, glue the motor onto the motor cage.
23 Next, place the Arduino in the acrylic box. Feed the wires through the hole of the cutout and tape the excess wires to the board.

24 To attach the string to the chute door, create a small knot with a loop and then screw a small screw into the MDF. Place the string over the 3D printed cylindrical piece to reduce the load of the chute.
25 Complete the project by winding the string onto the wheel, making the close position the start.

6.2 Testing & Validation

The notification system and motor underwent specific tests before being placed inside the donation bin. As a group, we rewrote the code for the notification system to determine the optimal point for the light to turn on. The final prototype is on a 1 to 4 scale. The light thus shines at a distance of 5cm in the prototype. The final product would send a notification at 20cm for the sensor, which equates to a distance of 25cm from the ceiling of the bin. Next, the motor underwent significant testing as it is an integral part of the entire donation bin. Firstly, the speed at which the motor rotates and the size of the wheel is a direct correlation. As the 3D printed wheel is a fixed system that cannot be adjusted, we decided to tune the speed of the motor. Our group ran tests on the timing and if it adheres to safety measures. A slower system is predictable and better suited for accessible individuals. In addition to the speed, the time where the chute is parallel to the ground is on a timer. Our group found that 15 seconds is enough time to place items onto the chute. The timing is adjustable in the Arduino code at the customer's request. Lastly, testing the finished product multiple times over a week helped us determine any problems that may occur. The testing experiments helped our group determine the optimal performance of our components. Knowing the performance levels, we are confident that the system is working at its highest capability and will continue working without problems.

7 Conclusions and Recommendations for Future Work

The accessible donation bin created many learning experiences where our team can benefit. Our group learned a valuable lesson during the final presentation of the project. On the morning of the presentation, we realized that the donation bin motor was not functioning because of the drained battery. Engineers perform many presentations throughout their careers and will find themselves in a similar situation. We attempted to fix the situation the morning off but were not successful. Instead, we began pivoting to show a video demonstration of the product rather than a live demonstration. We presented the slideshow but failed to notify the customer that there will not be a live demonstration. Upon reflecting, our group should have taken the situation and asked for rescheduling or embraced that the bin is not working. Telling the customer early in the presentation shows confidence and dismisses any confusion. The classroom is a learning environment where we can encounter problems and gain experience.

Another lesson we learned is time management. Our group finished the project the day before the deadline and completed it in a couple of days. After reflecting, we should have begun working on it earlier to perform more tests. The electronic components of the motor caused our group difficulties. Together we researched ways but could not find a distinct solution. The TA began to worry as we just had the exterior structure to show. In the next project, we can finish early and perform additional tests to have the project working during the presentation.

An extended time limit can aid our group in creating components that are more beneficial to the client's needs. Firstly, we would add a notification system that messages the customer's phone. The LED light in the prototype shows the benefit of a notification system, but the customer still requires to be near to bin. An SMS message reduces any physical trips taken to check the status of the bin. The SMS notification system can save time and increase efficiency. Secondly, another board is needed on the back of the chute opening. When the chute door is open, someone can reach in and grab items from the donation bin. The addition of a board attached to the chute door at a 90-degree angle can prevent theft. When the automatic chute door is parallel to the ground, the vertical board will create a seamless connection with the sides of the opening. The addition of a board is a simple and beneficial design. Lastly, the prototype benefits from having a constant power source. The motor and the notification system require electricity which a 9V battery cannot provide. Creating a circuit that receives its source from a wall outlet and adding a converter can have the accessible donation bin run without ever losing power.

8 Bibliography

MakerStore. "Electronics, Materials, and Merch." *MakerStore*, makerstore.ca/shop?olsPage=t%2Felectronics&page=2.

https://makerstore.ca/shop/ols/all

[1] https://creativecommons.org/licenses/by/3.0/us/

APPENDICES

9 APPENDIX I: Design Files

- **Cutout for Ultrasonic Sensor.pdf:** This is a pdf document that is ready to cut by the laser cutter to create two holes for the ultrasonic sensor.
- **Winch Wheel.STL:** This is an STL ready to be 3D printed using the Ultimaker Cura software.
- **Door Cutouts.pdf:** This is a file to cut out both the chute door and opening door on the front board.
- **Acrylic Box Part 1:** pdf: This file is the cutout for the notification system box and motor box and should be used twice.
- **Acrylic Box Part 2:** pdf: This file is the cutout for the notification system box and motor box and should be used twice
- **Two squares.pdf:** This file cuts out two holes on the smallest acrylic board used for the source cable and connecting wires.
- **Stepper_motor_code.ino:** This is the Arduino code for the stepper motor to output its specific actions.
- **Cylinder.STL:** This is the STL file that is ready to be 3D printed using the Ultimaker Cura software.
- **Top.pdf:** This is the pdf file of the top portion of the bin, ready to be cut into the MDF board.
- **Front.pdf:** This is the pdf file of the front portion of the bin, ready to be cut into the MDF board.
- **Right.pdf:** This is the pdf file of the right portion of the bin, ready to be cut into the MDF board.
- **Bottom.pdf:** This is the pdf file of the bottom portion of the bin, ready to be cut into the MDF board.
- **Rear.pdf:** This is the pdf file of the rear portion of the bin, ready to be cut into the MDF board.
- **left.pdf:** This is the pdf file of the left portion of the bin, ready to be cut into the MDF board.

Table 3. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Bill of Materials	6.1.1	4/10/22
Cutout for Ultrasonic Sensor.pdf	MakerRepo under project files	4/10/22
Winch Wheel.STL	MakerRepo under project files	4/10/22
Door Cutouts.pdf	MakerRepo under project files	4/10/22

Acrylic Box Part 1.pdf	MakerRepo under project files	4/10/22
Acrylic Box Part 2.pdf	MakerRepo under project files	4/10/22
Two squares.pdf	MakerRepo under project files	4/10/22
Stepper_motor_code.ino	MakerRepo under project files	4/10/22
Cylinder.STL	MakerRepo under project files	4/10/22
Top.pdf	MakerRepo under project files	4/10/22
Bottom.pdf	MakerRepo under project files	4/10/22
Left.pdf	MakerRepo under project files	4/10/22
Right.pdf	MakerRepo under project files	4/10/22
Front.pdf	MakerRepo under project files	4/10/22
Back.pdf	MakerRepo under project files	4/10/22

Link to MakerRepo: https://makerepo.com/NoahDoRego/1154.gng2101d22accessible-donation-bin