# Automated Single Stream Recycling Sorting Bin (ASSRSB)

Daniel Pogue
*Washington University in St. Louis*, d.pogue@wustl.edu

Robert O'Neill
*Washington University in St. Louis*, robert.oneill@wustl.edu

Javi Perez
*Washington University in St. Louis*, carlos.perez@wustl.edu

Joint Engineering Program

University of Missouri–St. Louis ▪ Washington University in St. Louis

ELEVATE YOUR FUTURE.
ELEVATE ST. LOUIS.

Our project was designed around the sole purpose of sorting single stream recyclables, at the user level, before they reach a single stream recycling sorting facility. This action is intended to increase the success of recycling, while still trying to maintain the level of convivence provided by single stream recycling bins.

JME 4110
Mechanical Engineering
Design Project

# Automated Single Stream Recycling Sorting Bin (ASSRSB)

Javi Perez
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# 1 INTRODUCTION

## 1.1 VALUE PROPOSITION / PROJECT SUGGESTION

As you probably know, there are many different sorting systems used by various manufacturers. It would be desirable to have a similar sorting system that uses multiple technologies to sort items, but that could easily be interchangeable with various items. Currently, recycling efforts are often costly, as humans need to sort single-stream recycling. It would be beneficial to have a system that sorts various plastic, paper, cardboard, glass, etc.

## 1.2 LIST OF TEAM MEMBERS


Javi Perez *(carlos.perez@wustl.edu)*

Daniel Pogue *(d.pogue@wustl.edu)*

Robert O'Neill *(robert.oneill@wustl.edu)*


# 2 BACKGROUND INFORMATION STUDY

## 2.1 DESGIN BRIEF

Our project is to design a single stream recycling sorting bin that automatically sorts individual pieces of plastic, paper, cardboard, glass, and metal. We will use both mechanical and electrical sensing devices to sort the recyclables into separate bins. This individual system will do the work of a single stream recycling facility on the front end, eliminating the issues of contaminated and broken materials that slow down the single stream recycling process.

## 2.2 BACKGROUND SUMMARY

Existing designs that most closely fits the description:

http://www.cpmfg.com/material-recovery-facility/single-stream-recycling/single-stream-recycling-equipment/

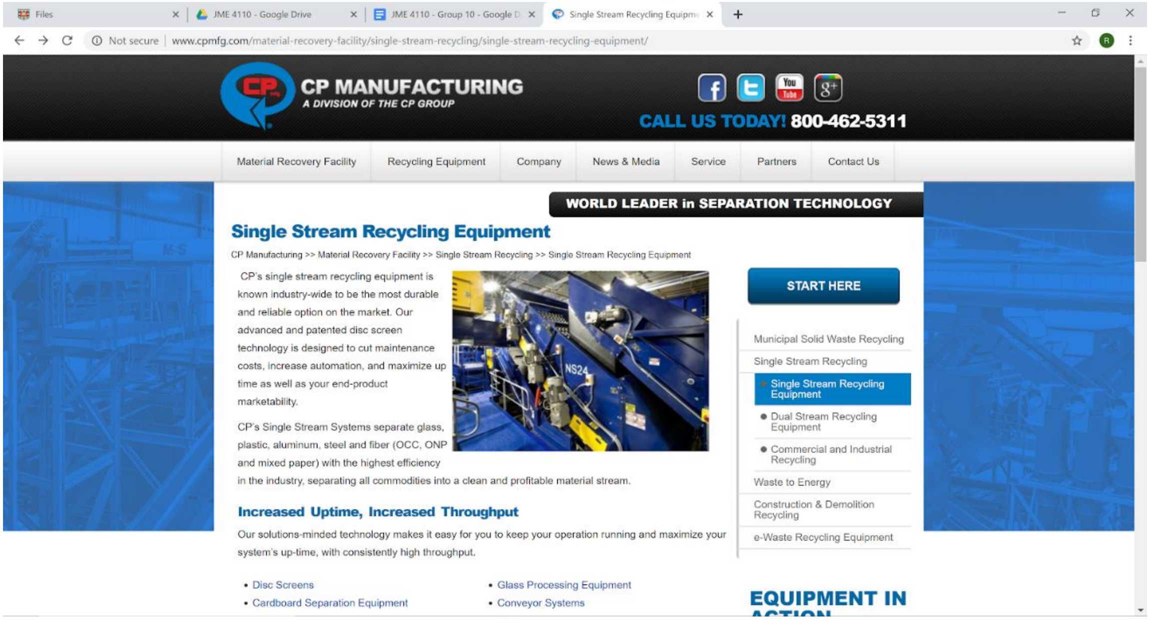



Figure 1: Existing Design 1

https://greenmachine.com/solutions/single-stream-recycling-equipment/

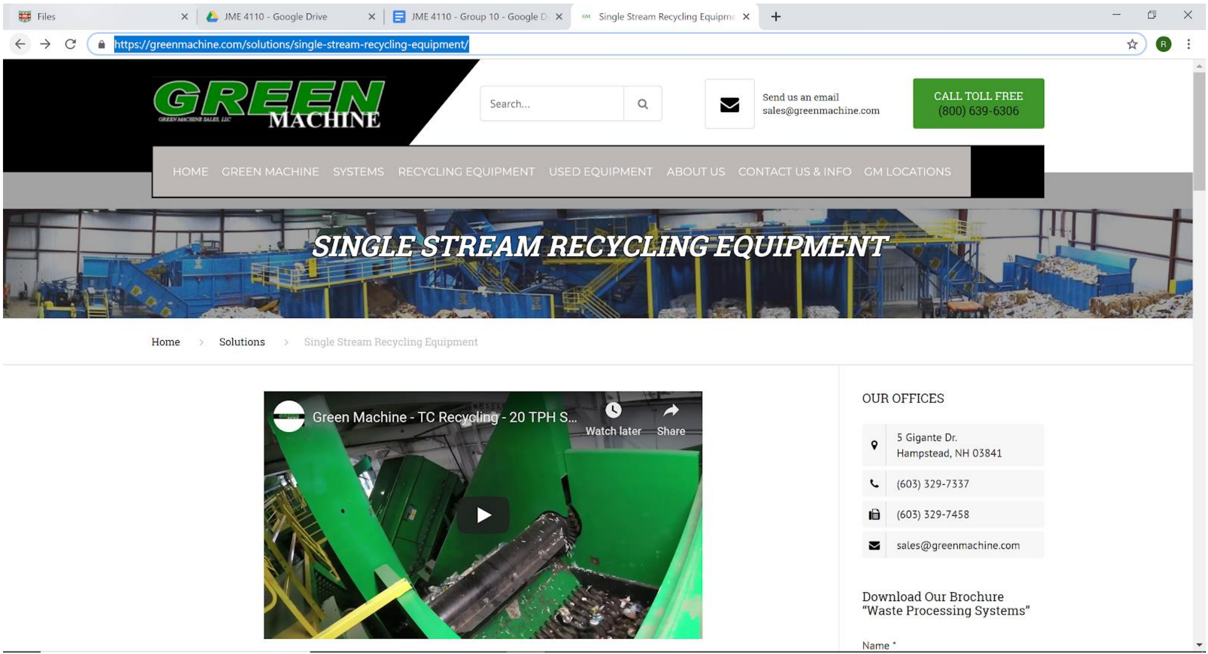



Figure 2: Existing Design 2

The most significant risk to the success of the design process:

https://www.greenwaste.com/about-us/material-recovery-facility-mrf

The sheer size of single stream recycling facilities makes it impossible for us to design and build a working prototype that is capable of sorting recyclables at a comparable rate, or anywhere close for that matter.

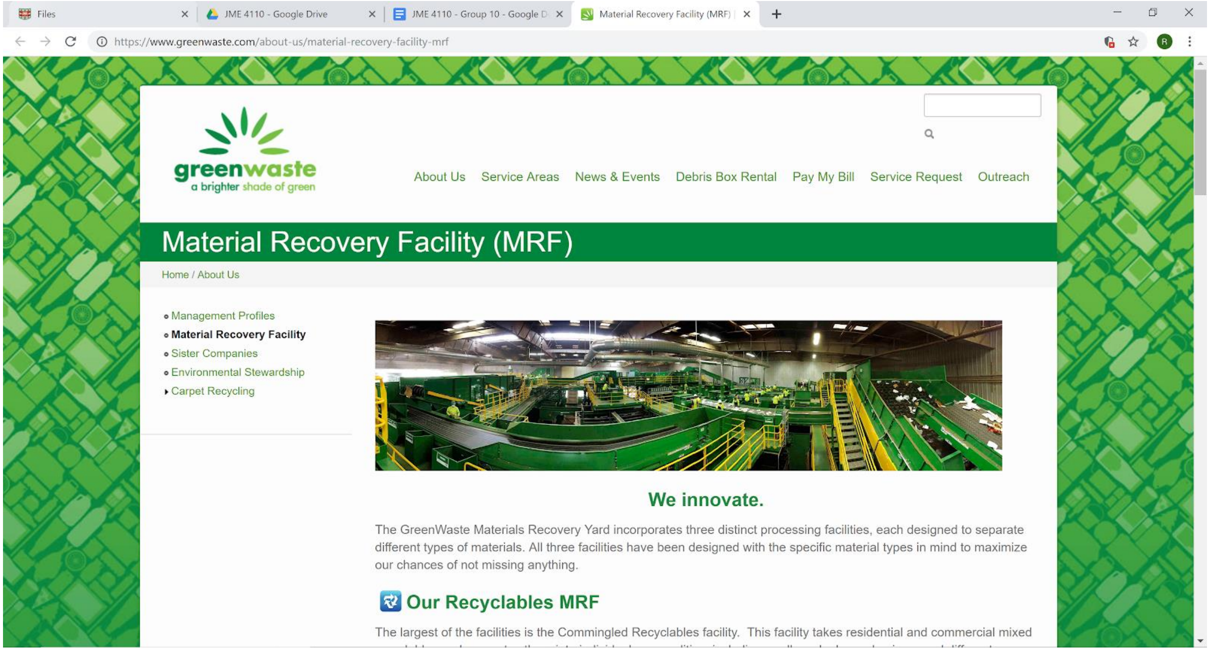



**Figure 3: Risk to Design**

Standard that is most relevant to the design:

Occupational Safety and Health Standards 29 CFR 1910 Subpart O**:** Machinery and Machine Guarding.

https://www.osha.gov/SLTC/machineguarding/standards.html

Since we plan on having moving parts in our design it is important to protect users from hazards.

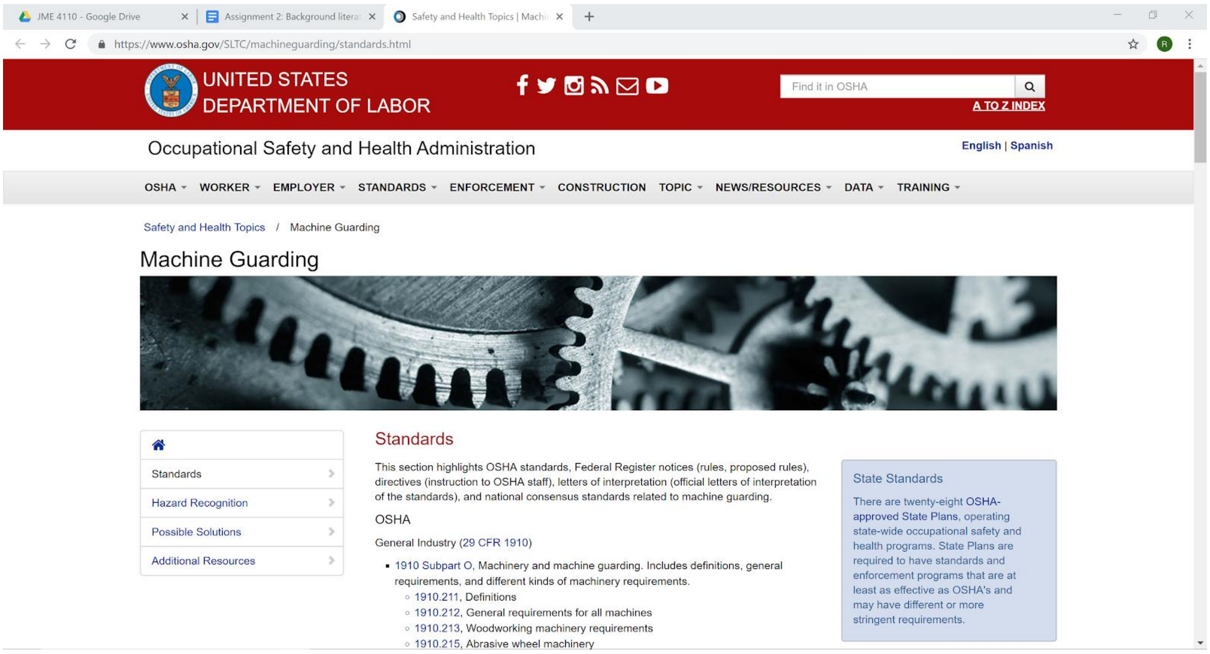



**Figure 4: Most Relevant Standard**

# 3 CONCEPT DESIGN AND SPECIFICATION

## 3.1 USER NEEDS AND METRICS

### 3.1.1 Record of the user needs interview

Table 1: User Needs Interview Record

| **Project/Product Name: Automated Single Stream Recycling Sorting Bin (ASSRSB)** | | | |
|---|---|---|---|
| Customer: Craig Giesmann<br><br>Address: Washington University<br>Willing to do follow up? Yes<br><br>Type of user: Everyday | | Interviewer(s): Robert O'Neill/Javi Perez/Daniel Pogue<br><br>Date: 06/24/19<br><br>Currently uses: Single Stream Recycling Bins or *None* | |
| Question | Customer Statement | Interpreted Need | Importance |
| How often do you use recycling bins on campus? | *1-2 times a week (only on campus 1-2 times a week).* | *Readily available 24/7 (assuming sustained maintenance).* | *5* |
| Are there any barriers preventing you from recycling? | *No, single stream bins are all over campus so it is convenient.* | *For a functioning system have multiple units.* | *2* |
| What's the most common object you recycle? | *Beverage containers; plastic, metal, glass, but mostly plastic.* | *Be able to sort plastic, glass, and metal.* | *5* |

| | | | |
|---|---|---|---|
| What would make the recycling process more convenient? | *Nothing, single stream bins located all over campus.* | *Have a comparable amount of bins to regular single stream bins.* | *2* |
| How many recyclables do you produce in an average week? | *10 items a week including off-campus. I have a daily newspaper prescription.* | *Have a significant storage capacity.* | *4* |
| Where would this bin be best utilized on a college campus? | *Cafeteria* | *Placed near a location where large amounts of recyclables are created.* | *2* |
| Where would this bin best be utilized in an office building? | *Cafeteria or building entrance if no cafeteria.* | *Placed near a location where large amounts of recyclables are created.* | *2* |
| Would you be willing to open and close a lid? | *Yes, but hands-free is ideal.* | *Hands-free opening/device utilization.* | *4* |
| Is seeing the recyclables sorted, inside the bin important to you? | *No..., labeling would be nice.* | *Visibility of recycling or functional labeling.* | *3* |
| Would instructions on how to use the bin be well received or overlooked? | *Would be well received but needs to be simple (can be read in a few seconds).* | *Functional labeling.* | *3* |

### 3.1.2 List of identified metrics

**Table 2: Identified Metrics**

| Metric Number | Associated Needs | Metric | Units | Min Value | Max Value |
|---|---|---|---|---|---|
| 1 | 1 | Power Outlet | Integer | 1 | 4 |
| 2 | 10 | Time | Seconds | 0 | 100 |
| 3 | 4 | Volume | ft^3 | 0 | 100 |
| 4 | 5 | Length | ft. | 1 | 4 |
| 5 | 6,7 | Process, Automated | Percent | 0 | 100 |
| 6 | 2,8 | Cost | Dollars | 1 | 1000 |
| 7 | 9 | Weight | lbs. | 0 | 100 |
| 8 | 3 | Sorting Accuracy | Percent | 0 | 100 |
| 9 | 2 | Parts/Hardware | Integer | 1 | 200 |

### 3.1.3 Table/list of quantified needs equations

**Table 3: Quantified Needs**

| Need Number | Need | Importance |
|---|---|---|
| 1 | ASSRSB has a constant power source | 5 |
| 2 | ASSRSB is easily manufactured | 4 |
| 3 | ASSRSB can compartmentalize materials | 5 |
| 4 | ASSRSB has the capacity for 24 hours of use | 5 |
| 5 | ASSRSB needs to fit within a building entrance | 5 |
| 6 | ASSRSB must be hands free | 4 |
| 7 | ASSRSB must be user friendly | 5 |
| 8 | ASSRSB cost | 3 |
| 9 | ASSRSB has ease of mobility | 1 |
| 10 | ASSRSB successfully sorts recyclables in a practical amount of time | 5 |

## 3.2 CONCEPT DRAWINGS

Concept 1: Conveyor Belt Bin

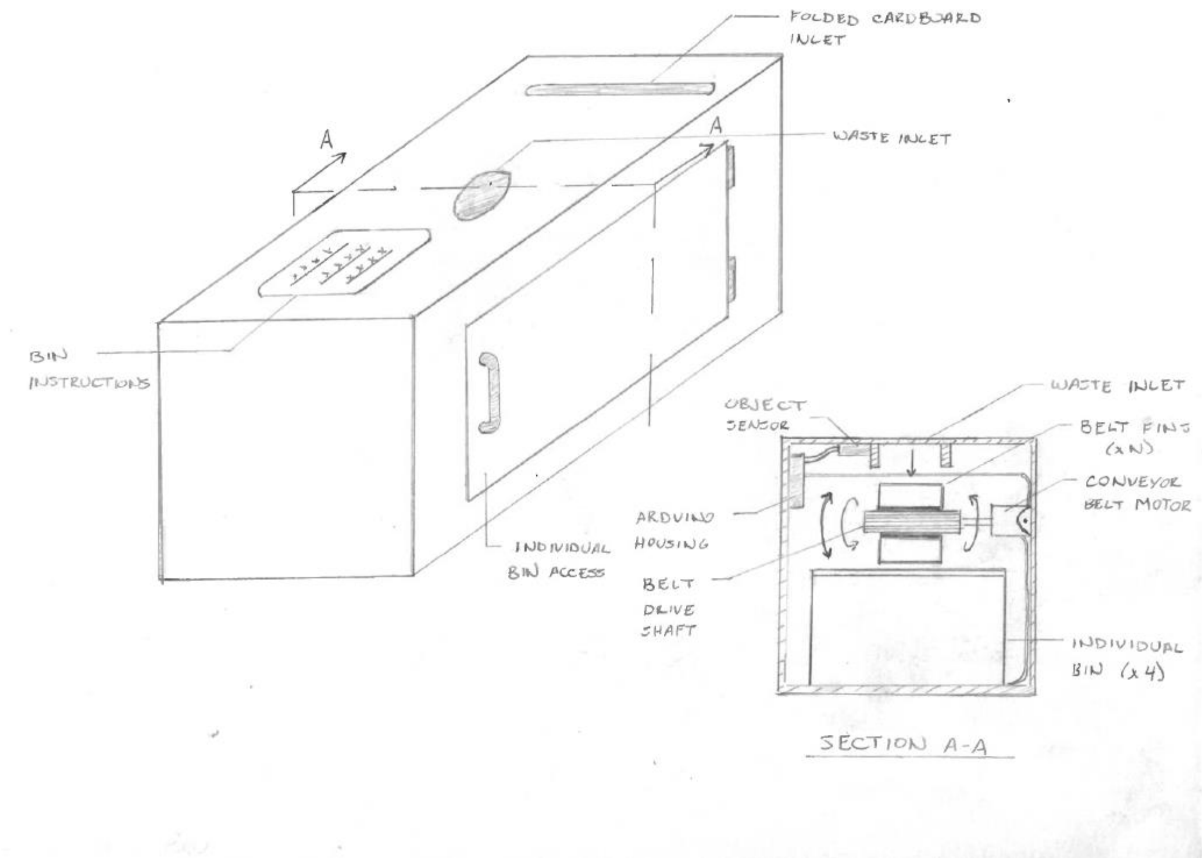



Figure 5: Concept 1 Drawing

Concept 2: Rotating Drum Bin

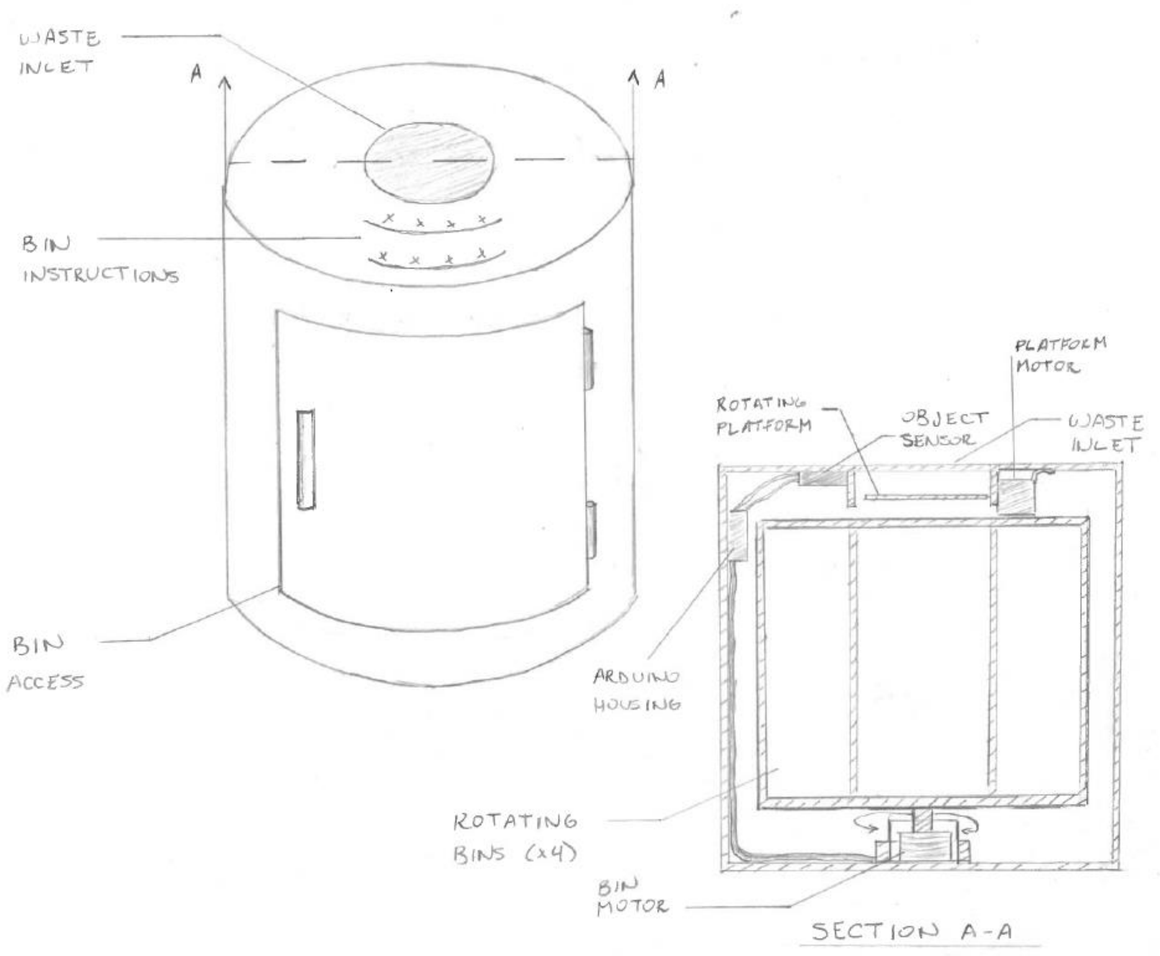



**Figure 6: Concept 2 Drawing**

Concept 3: Vacuum Suction Sorting Bin

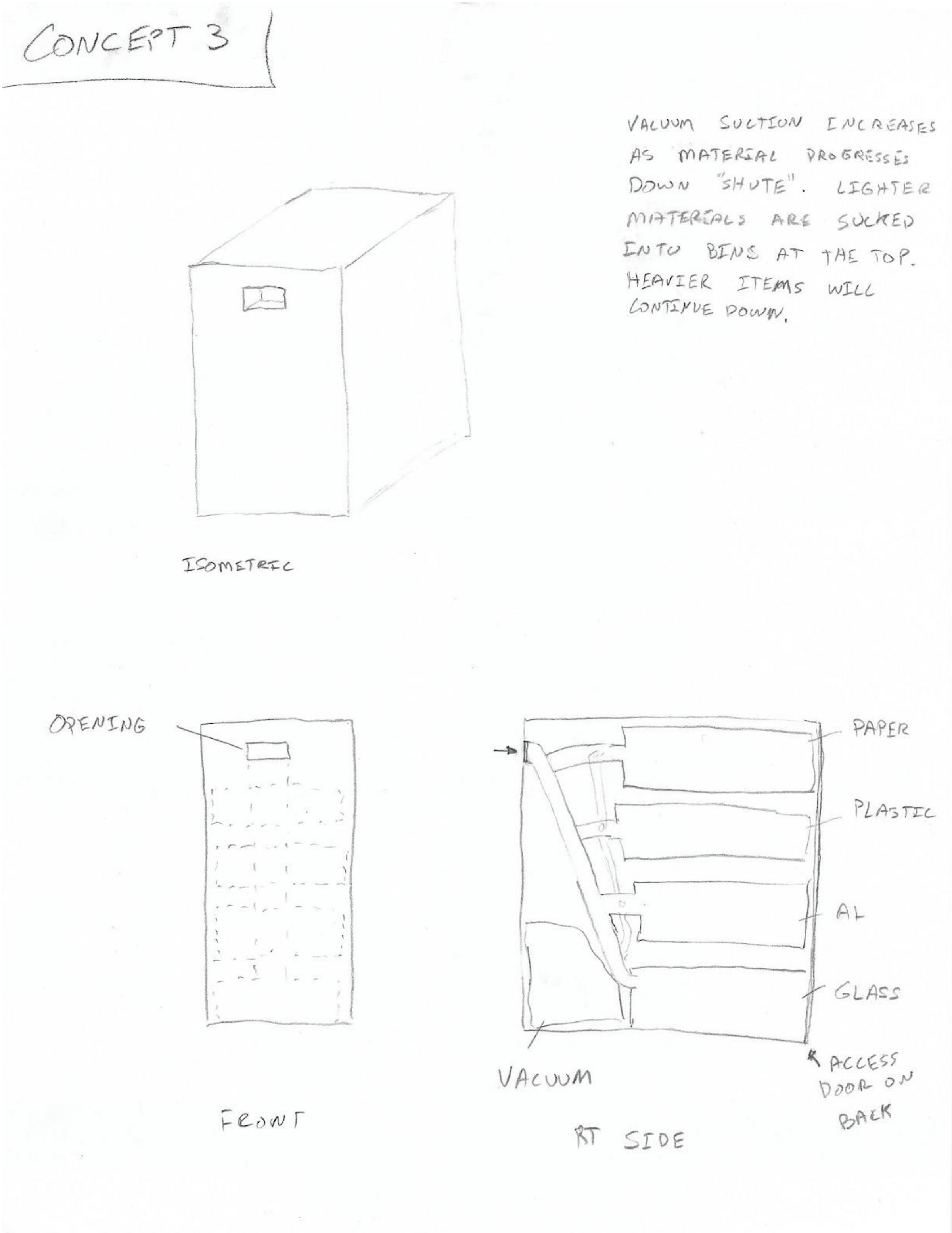



**Figure 7: Concept 3 Drawing**

Concept 4: Push Button Sorting Bin

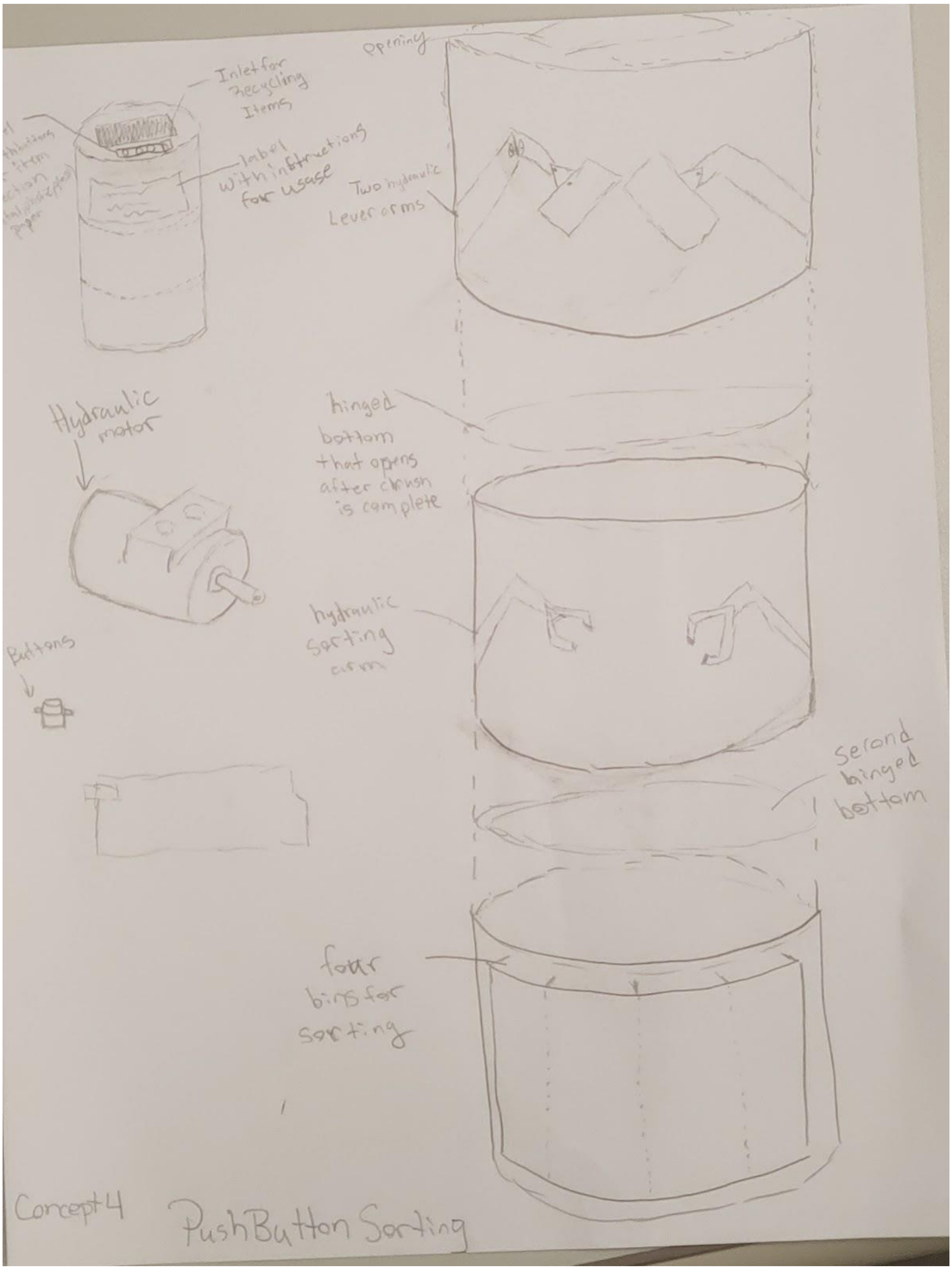



Figure 8: Concept 4 Drawing

## 3.3 A CONCEPT SELECTION PROCESS.

### 3.3.1 Concept scoring

**Table 4: Concept 1 Quantified Needs Matrix**

| CONCEPT 1 "Conveyer Sorting" | | Metric | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Power outlet | Time | Volume | Length | Percent of the process is automated | Cost | Weight | Sorting Accuracy | Number of parts | Need Happiness | Importance Weight (all entries should add up to 1) | Total Happiness Value |
| Need# | Need | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | | |
| 1 | ASSRSB has a constant power source | 1 | | | | | | | | | 1 | 0.05 | 0.05 |
| 2 | ASSRSB is easily manufacturable | | | | | | 0.3 | | | 0.7 | 0 | 0.1 | 0 |
| 3 | ASSRSB can compartmentalize materials | | | | | | | | 1 | | 0.85 | 0.125 | 0.10625 |
| 4 | ASSRSB has the capacity for 24 hours of use | | | 1 | | | | | | | 0.76 | 0.125 | 0.095 |
| 5 | ASSRSB needs to fit within a building entrance | | | | 1 | | | | | | 0 | 0.1 | 0 |
| 6 | ASSRSB must be hands free | | | | | 1 | | | | | 1 | 0.125 | 0.125 |
| 7 | ASSRSB must be user friendly | | | | | 1 | | | | | 1 | 0.15 | 0.15 |
| 8 | ASSRSB cost | | | | | | 1 | | | | 0 | 0.05 | 0 |
| 9 | ASSRSB ease of mobility | | | | | | | 1 | | | 0.6 | 0.025 | 0.015 |
| 10 | ASSRSB sorting time | | 1 | | | | | | | | 0.85 | 0.15 | 0.1275 |
| Units | | Integer | Seconds | ft^3 | ft | Percentage | Dollars | lb | Percentage | Integer | Total Happiness | | 0.52625 |
| Best Value | | 1 | 0 | 100 | 1 | 100 | 1 | 0 | 100 | 0 | | | |
| Worst Value | | 4 | 100 | 0 | 4 | 0 | 1000 | 100 | 0 | 200 | | | |
| Actual Value | | 1 | 15 | 24 | 4 | 100 | 1000 | 40 | 85 | 150 | | | |
| Normalized Metric Happiness | | 1 | 0.85 | 0.76 | 0 | 1 | 0 | 0.6 | 0.85 | 0.75 | | | |

**Table 5: Concept 2 Quantified Needs Matrix**

| CONCEPT 2 "Rotating sorting bin" | | Metric | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Power outlet | Time | Volume | Length | Percent of the process is automated | Cost | Weight | Sorting Accuracy | Number of parts | Need Happiness | Importance Weight (all entries should add up to 1) | Total Happiness Value |
| Need# | Need | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | | |
| 1 | ASSRSB has a constant power source | 1 | | | | | | | | | 1 | 0.05 | 0.05 |
| 2 | ASSRSB is easily manufacturable | | | | | | 0.3 | | | 0.7 | 0.15 | 0.1 | 0.015 |
| 3 | ASSRSB can compartmentalize materials | | | | | | | | 1 | | 0.81 | 0.125 | 0.10125 |
| 4 | ASSRSB has the capacity for 24 hours of use | | | 1 | | | | | | | 0.9 | 0.125 | 0.1125 |
| 5 | ASSRSB needs to fit within a building entrance | | | | 1 | | | | | | 0.25 | 0.1 | 0.025 |
| 6 | ASSRSB must be hands free | | | | | 1 | | | | | 1 | 0.125 | 0.125 |
| 7 | ASSRSB must be user friendly | | | | | 1 | | | | | 1 | 0.15 | 0.15 |
| 8 | ASSRSB cost | | | | | | 1 | | | | 0.5 | 0.05 | 0.025 |
| 9 | ASSRSB ease of mobility | | | | | | | 1 | | | 0.7 | 0.025 | 0.0175 |
| 10 | ASSRSB sorting time | | 1 | | | | | | | | 0.9 | 0.15 | 0.135 |
| Units | | Integer | Seconds | ft^3 | ft | Percentage | Dollars | lb | Percentage | Integer | Total Happiness | | 0.60375 |
| Best Value | | 1 | 0 | 100 | 1 | 100 | 1 | 0 | 100 | 0 | | | |
| Worst Value | | 0 | 100 | 0 | 4 | 0 | 1000 | 100 | 0 | 200 | | | |
| Actual Value | | 1 | 10 | 28 | 3 | 100 | 500 | 30 | 100 | 100 | | | |
| Normalized Metric Happiness | | 1 | 0.9 | 0.9 | 0.25 | 1 | 0.5 | 0.7 | 0.81 | 0.5 | | | |

**Table 6: Concept 3 Quantified Needs Matrix**

| CONCEPT 3 "Suction sorting" | | Metric | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Power outlet | Time | Volume | Length | Percent of the process is automated | Cost | Weight | Sorting Accuracy | Number of parts | Need Happiness | Importance Weight (all entries should add up to 1) | Total Happiness Value |
| Need# | Need | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | | |
| 1 | ASSRSB has a constant power source | 1 | | | | | | | | | 1 | 0.05 | 0.05 |
| 2 | ASSRSB is easily manufacturable | | | | | | 0.3 | | | 0.7 | 0.15 | 0.1 | 0.015 |
| 3 | ASSRSB can compartmentalize materials | | | | | | | | 1 | | 0.75 | 0.125 | 0.09375 |
| 4 | ASSRSB has the capacity for 24 hours of use | | | 1 | | | | | | | 0.7 | 0.125 | 0.0875 |
| 5 | ASSRSB needs to fit within a building entrance | | | | 1 | | | | | | 0.375 | 0.1 | 0.0375 |
| 6 | ASSRSB must be hands free | | | | | 1 | | | | | 1 | 0.125 | 0.125 |
| 7 | ASSRSB must be user friendly | | | | | 1 | | | | | 1 | 0.15 | 0.15 |
| 8 | ASSRSB cost | | | | | | 1 | | | | 0.5 | 0.05 | 0.025 |
| 9 | ASSRSB ease of mobility | | | | | | | 1 | | | 0.55 | 0.025 | 0.01375 |
| 10 | ASSRSB sorting time | | 1 | | | | | | | | 0.9 | 0.15 | 0.135 |
| Units | | Integer | Seconds | ft^3 | ft | Percentage | Dollars | lb | Percentage | Integer | Total Happiness | | 0.58375 |
| Best Value | | 1 | 0 | 100 | 1 | 100 | 1 | 0 | 100 | 0 | | | |
| Worst Value | | 0 | 100 | 0 | 4 | 0 | 1000 | 100 | 0 | 200 | | | |
| Actual Value | | 1 | 10 | 30 | 2.5 | 100 | 500 | 45 | 75 | 150 | | | |
| Normalized Metric Happiness | | 1 | 0.9 | 0.7 | 0.375 | 1 | 0.5 | 0.55 | 0.75 | 0.25 | | | |

**Table 7: Concept 4 Quantified Needs Matrix**

| CONCEPT 4 "Sorting arm with compactor" | | Metric | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Power outlet | Time | Volume | Length | Percent of the process is automated | Cost | Weight | Sorting Accuracy | Number of parts | Need Happiness | Importance Weight (all entries should add up to 1) | Total Happiness Value |
| Need# | Need | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | | |
| 1 | ASSRSB has a constant power source | 1 | | | | | | | | | 1 | 0.05 | 0.05 |
| 2 | ASSRSB is easily manufacturable | | | | | | 0.3 | | | 0.7 | 0.003 | 0.1 | 0.0003 |
| 3 | ASSRSB can compartmentalize materials | | | | | | | | 1 | | 0.9 | 0.125 | 0.1125 |
| 4 | ASSRSB has the capacity for 24 hours of use | | | 1 | | | | | | | 0.63 | 0.125 | 0.07875 |
| 5 | ASSRSB needs to fit within a building entrance | | | | 1 | | | | | | 0 | 0.1 | 0 |
| 6 | ASSRSB must be hands free | | | | | 1 | | | | | 1 | 0.125 | 0.125 |
| 7 | ASSRSB must be user friendly | | | | | 1 | | | | | 1 | 0.15 | 0.15 |
| 8 | ASSRSB cost | | | | | | 1 | | | | 0.01 | 0.05 | 0.0005 |
| 9 | ASSRSB ease of mobility | | | | | | | 1 | | | 0.6 | 0.025 | 0.015 |
| 10 | ASSRSB sorting time | | 1 | | | | | | | | 0.85 | 0.15 | 0.1275 |
| Units | | Integer | Seconds | ft^3 | ft | Percentage | Dollars | lb | Percentage | Integer | Total Happiness | | 0.51705 |
| Best Value | | 1 | 0 | 100 | 1 | 100 | 1 | 0 | 100 | 0 | | | |
| Worst Value | | 0 | 100 | 0 | 4 | 0 | 1000 | 100 | 0 | 200 | | | |
| Actual Value | | 1 | 15 | 37 | 4 | 100 | 900 | 40 | 90 | 150 | | | |
| Normalized Metric Happiness | | 1 | 0.85 | 0.63 | 0 | 1 | 0.01 | 0.6 | 0.9 | 0.25 | | | |

### 3.3.2 Physical Feasibility Analysis

Concept 1: Conveyor Sorting Bin

Our first concept design involves the use of sensors to determine what each recyclable item is, with respect to material. The item will be dropped into the system through the waste inlet, land on a conveyor belt, and then sent to its respective bin, based on the material. Once the object on the conveyor is aligned with the specific bin, the whole conveyor will rotate to drop the object into the bin. To make the system function properly, it will require the synchronization of two motors, a sensor (or multiple sensors depending on sensor capabilities), and some sort of programmable processing platform (such as an Arduino). Given the complexity of the design, this concept is entirely possible with the necessary knowledge, time, and resources. For the sake of our design project, this concept is not possible. Even though building the structure of the system is feasible, building the internal components that make the system operate autonomously is not.

Concept 2: Rotating Sorting Bin

Our second concept design uses sensor(s) to determine what the material of each recyclable item is. The sorting process will begin at the waste inlet, where item will be dropped in, and rest on a rotating platform. Once the material is identified, a motor will activate and vertically align the specific material bin with the platform. The platform will then rotate to drop the item into the bin. To make this system function as we intended, it will require the same level of synchronization between the sensor, the programmable processing platform (such as an Arduino), and the two electric motors that distribute the item. Even though this concept is complex, it is possible if the material/equipment cost is low and a sensor can be found that can detect different materials.

Concept 3: Vacuum Suction Sorting Bin

The third concept uses suction to separate different materials. All items are put into the same opening and as they progress downward, depending on the material weight, are sorted into bins. The four bin inlets are connected to one vacuum. The bins at the bottom, closest to the vacuum will have a higher suction force than the top one. The physical design is feasible. However, extensive calculations and testing will be required to achieve adequate sorting results.

Concept 4: Push Button Sorting Bin

Our final concept design uses multiple hydraulic arms to compact the recyclables entering the receptacle and also pick up and sort them into bins. The second set of arms (the sorters) communicate with the push buttons at the top of the machine via Arduino software to tell the arms where to place the crushed items. Not all items that enter the machine will be crushed, items like glass and paper will not need to be crushed and the machine will know to allow those items to pass through. The machine incorporates four bins to separate the items and uses a series of hinged doors to help split up the process between crushing and sorting. There are four hydraulic arms to maximize crushing potential and to speed up the sorting of multiple items, each of the arms with employ its own hydraulic motor. Lastly on the front there will be carefully worded instructions on how to use the machine. The design is possible because it uses technologies like a vending machine to select what time the person wants sorted and then effectively place the item into the bin.

### 3.3.3 Final summary statement

Based on our four design concepts, the winner is concept 2, the Rotating Sorting Bin. The reason this concept is the winner, is because it effectively sorts through recyclables with minimal effort imparted on bystanders. It sorts faster than the other concepts and allows for easier communication between the machine and the user. It also has the highest chance for successful sorting since it employs less components. The fourth concept was ruled out because of the complexity of its design and the speed in which it sorts. Concept three uses vacuum sorting to suction the falling recyclables into proper slots, this concept was eliminated because of the potential inconsistencies of successful sorting. The first concept was readily eliminated based on what was said above, "Even though building the structure of the system is feasible, building the internal components that make the system operate autonomously is not" since it cannot be easily manufactured it is not a prime candidate.

## 3.4 PROPOSED PERFORMANCE MEASURES FOR THE DESIGN

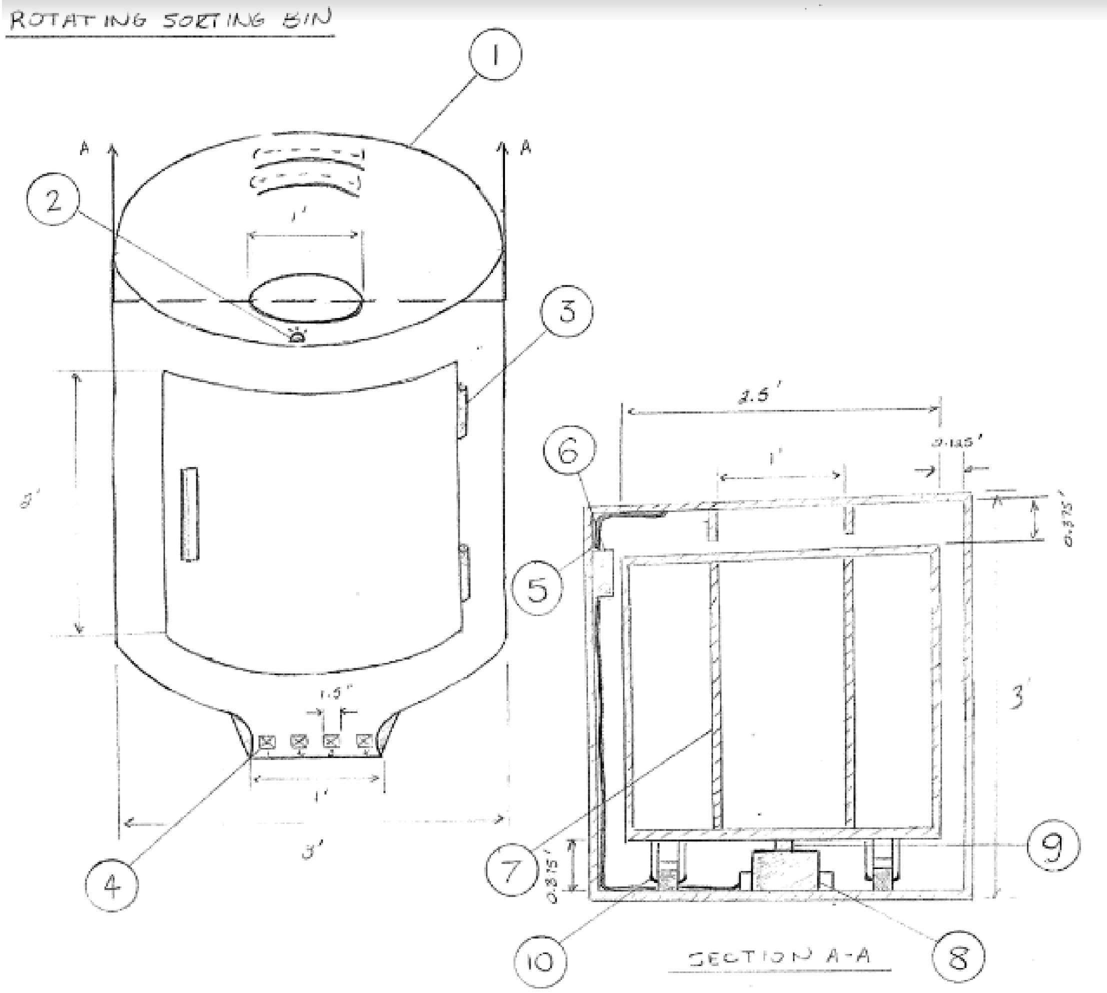
The single user need that will be considered as the overall performance measure will be user need 10, the “ASSRSB successfully sorts recyclables in a practical amount of time.” The reason this need will be the overall performance measure is because it defines what we intend to accomplish with the system in an efficient fashion. The system needs to be able to handle a steady flow of recyclables quickly, to justify its purpose.

## 3.5 REVISION OF SPECIFICATIONS AFTER CONCEPT SELECTION

In choosing concept two, we wanted to utilize the rotation of the bin, however we believe that the full autonomy of the concept will not be feasible given the time constraints and budget. With that, a combination of concept two and concept four will be the driving design. Specifically, the mechanical rotation displayed in concept two and the bush button activation shown in concept four.

# 4 EMBODIMENT AND FABRICATION PLAN

## 4.1 EMBODIMENT/ASSEMBLY DRAWING




BILL OF MATERIALS:

| ITEM # | DESCRIPTION | QUANTITY | SUPPLIER | CATALOG # | PRICE |
|---|---|---|---|---|---|
| 1 | PETG 1/2" SHEETS 48",96" | 1 | McMASTER-CARR | 7581SK85 | $104.89 |
| 2 | ELEGOO ELEC. PACK | 1 | AMAZON | MEGA2560 | $6.96 |
| 3 | SPRING HINGES | 2 | McMASTER-CARR | 1479A42 | $43.76 |
| 4 | ELEGOO ELEC. PACK | 1 | AMAZON | MEGA 2560 | $6.96 (0) |
| 5 | 16 GAUGE AUDIO CABLE | 1 | McMASTER-CARR | 7260T15 | $8.12 |
| 6 | ARDUINO | 1 | AMAZON | MEGA 2560 | $30.80 |
| 7 | 55 GAL PLASTIC DRUM | 1 | AMAZON | RC55 | $49.95 |
| 8 | DC MOTOR | 1 | NSCD | D437015 | $46.55 |
| 9 | — | | | | |
| 10 | 2" SWIVEL CASTER | 4 | HOME DEPOT | 841102 | $13.76 |

Figure 9: Embodiment/Assembly Drawing

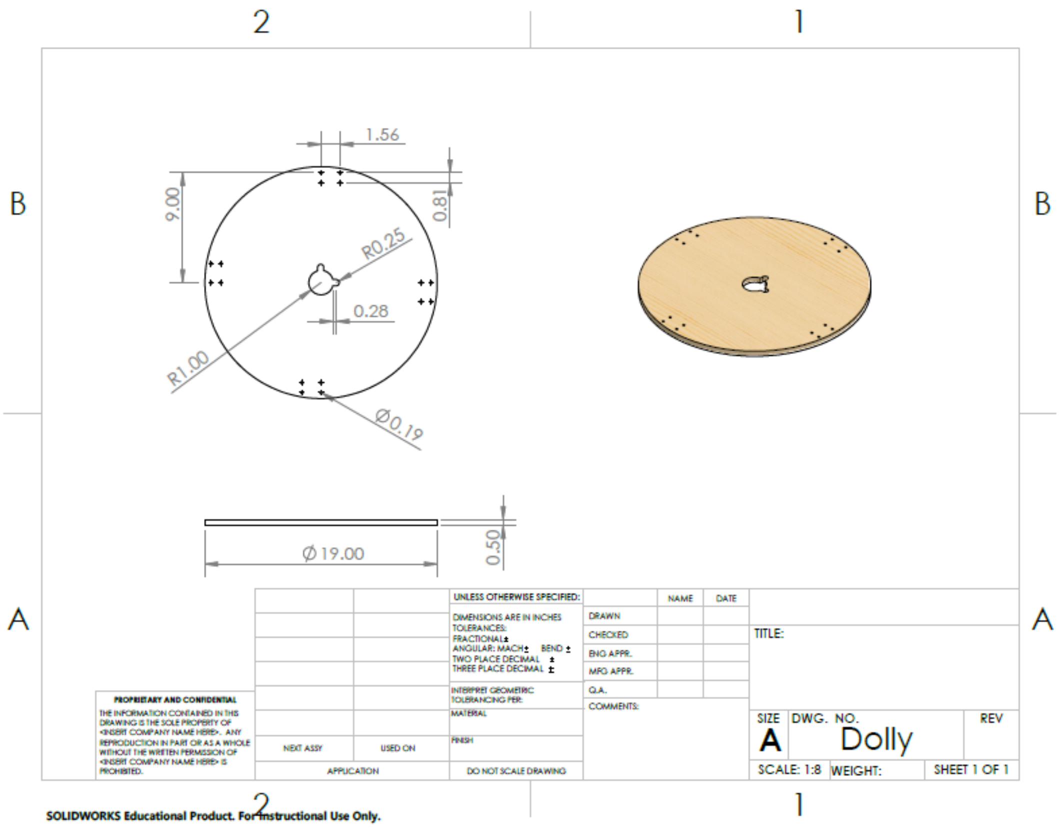
## 4.2 PARTS LIST

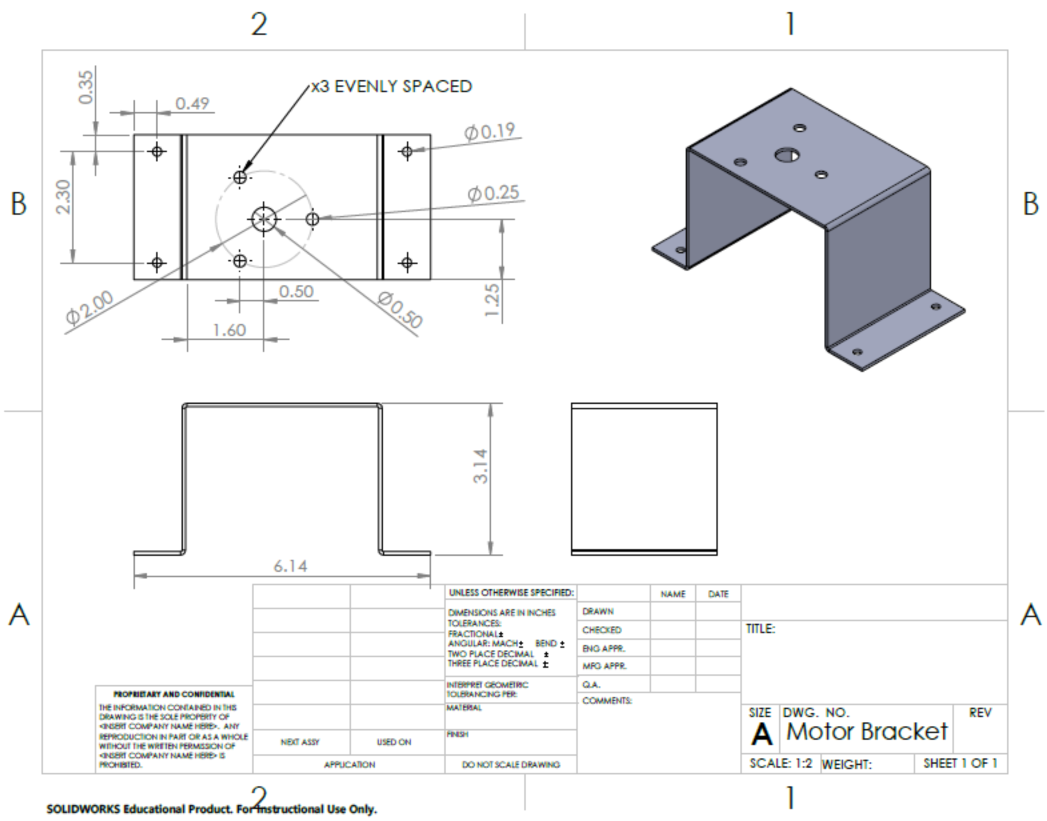
**Table 8: Initial Parts List**

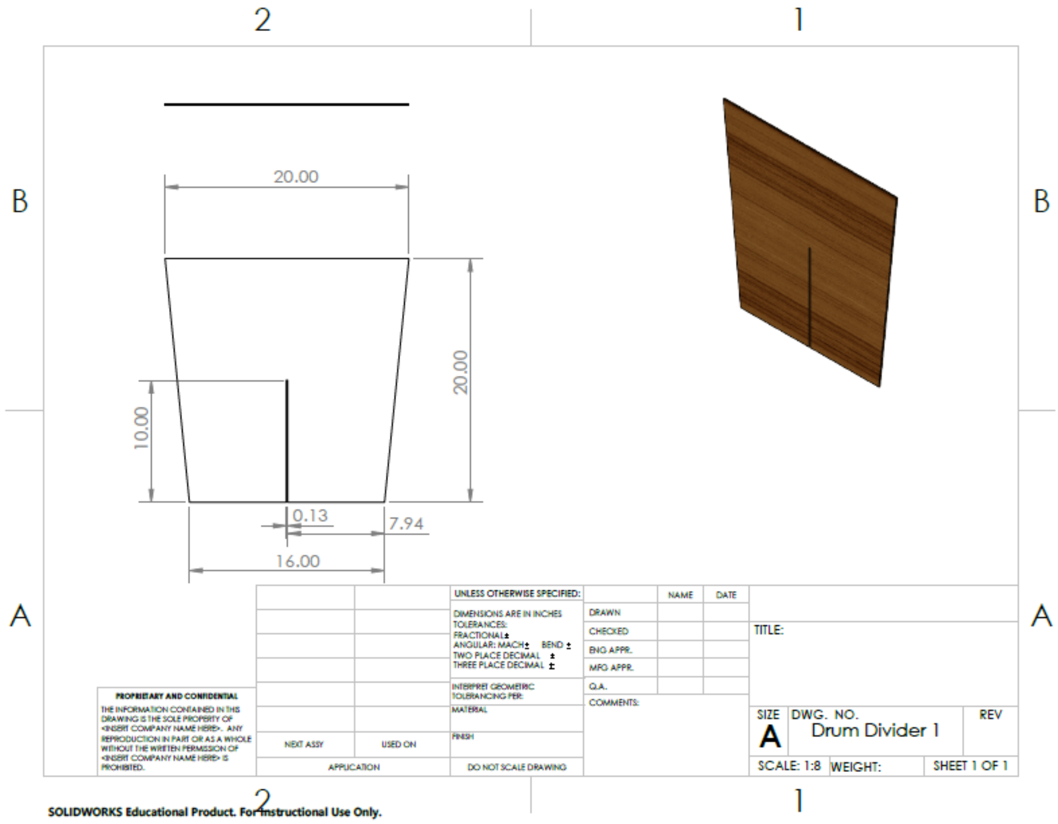
| Description | Part # | Quantity/ Unit | Price/ Unit | Vendor Website |
|---|---|---|---|---|
| Heavy Duty Plastic Drum | 4319T29 | 1 ea. | $89.55 | https://www.mcmaster.com/4319t29 |
| Zinc-Galvanized Low-Carbon Steel Sheet (24”x48”x0.024") | 8943K15 | 2 ea. | $23.66 | https://www.mcmaster.com/8943k15 |
| Zinc-Galvanized Low-Carbon Steel Sheet (24”x48”x0.071") | 8943K18 | 1 ea. | $57.18 | https://www.mcmaster.com/8943k18 |
| Zinc-Plated Blind Rivets | 97519A050 | 1 pack | $6.39 | https://www.mcmaster.com/97519a050 |
| Tight-Quarters Swivel Caster | 22785T43 | 4 ea. | $5.83 | https://www.mcmaster.com/22785t43 |
| Steel Flat Head Solid Rivets (3/16”) | 97032A245 | 1 pack | $6.96 | https://www.mcmaster.com/97032a245 |
| Hormann D437015 Replacement DC Motor for 5500 & 7500 Garage Door Opener (Nidec DC Motor) | D437015 | 1 ea. | $46.55 | https://www.northshorecommercialdoor.com/horman-d437015-motor.html?gclid=Cj0KCQjw9pDpBRCkARIsAOzRziu2Knk1hyuPicE8LsDy0aSTsapnuj49LUaaAIGrdx2HDvddwHa_GSAaArK3EALw_wcB |
| Roller Chain Sprocket | 2737T261 | 1 ea. | $22.71 | https://www.mcmaster.com/2737t261 |
| SunFounder Mega 2560 R3 ATmega2560-16AU Board Compatible with Arduino | MEGA2560KIT | 1 ea. | $34.99 | https://www.amazon.com/SunFounder-ATmega2560-16AU-Board-Compatible-Arduino/dp/B00D9NA4CY/ref=sr_1_1_sspa?keywords=mega+2560&qid=1563197736&s=gateway&sr=8-1-spons&psc=1 |

| | | | | |
|---|---|---|---|---|
| 16-Gauge Audio Cable | 8260T13 | 1 ea. (10ft) | $8.12 | https://www.mcmaster.com/8260t13-8260T131 |
| TiAlN-Coated High-Speed Steel Drill Bit | 3178A451 | 1 ea. | $6.26 | https://www.mcmaster.com/3178a451 |
| Black-Oxide High-Speed Steel Drill Bit | 2901A183 | 4 ea. | $2.40 | https://www.mcmaster.com/2901a183 |
| 14 AWG 3 Conductor 3-Prong Power Cord with Open Wiring, 15 Amp Max, 6 ft. Replacement Power Cord with Open End, Pigtail Open Cable | 6543854486 | 1 ea. | 12.99 | https://www.amazon.com/Conductor-3-Prong-Wiring-Replacement-Pigtail/dp/B07MCBPG5V |
| Amazon Basics 9 Volt Everyday Alkaline Battery - Pack of 4 | 192233010984 | 1 ea. | 6.99 | https://www.amazon.com/AmazonBasics-Everyday-Alkaline-Batteries-8-Pack/dp/B0774D64LT/ref=sr_1_1_sspa?crid=XJOLVUG35P2&keywords=9v%2Bbattery&qid=1563230896&s=gateway&sprefix=9v%2Caps%2C164&sr=8-1-spons&th=1 |
| 14 AWG 3 Conductor 3-Prong Power Cord with Open Wiring, 15 Amp Max, 6 ft. Replacement Power Cord with Open End, Pigtail Open Cable | 6543854486 | 1 ea. | 12.99 | https://www.amazon.com/Conductor-3-Prong-Wiring-Replacement-Pigtail/dp/B07MCBPG5V |
| | | **Total Cost:** | **$371.94** | |

## 4.3 DRAFT DETAIL DRAWINGS FOR EACH MANUFACTURED PART

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Drum Divider 1
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PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
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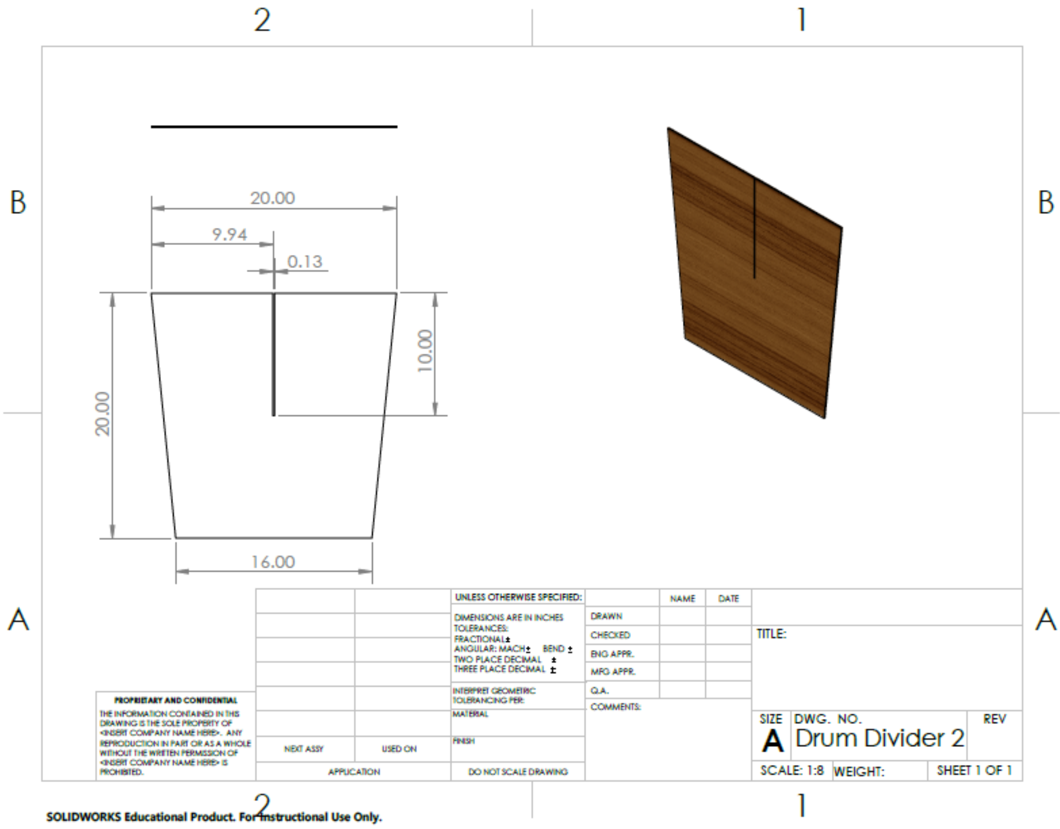
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Drum Divider 2
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SHEET 1 OF 1
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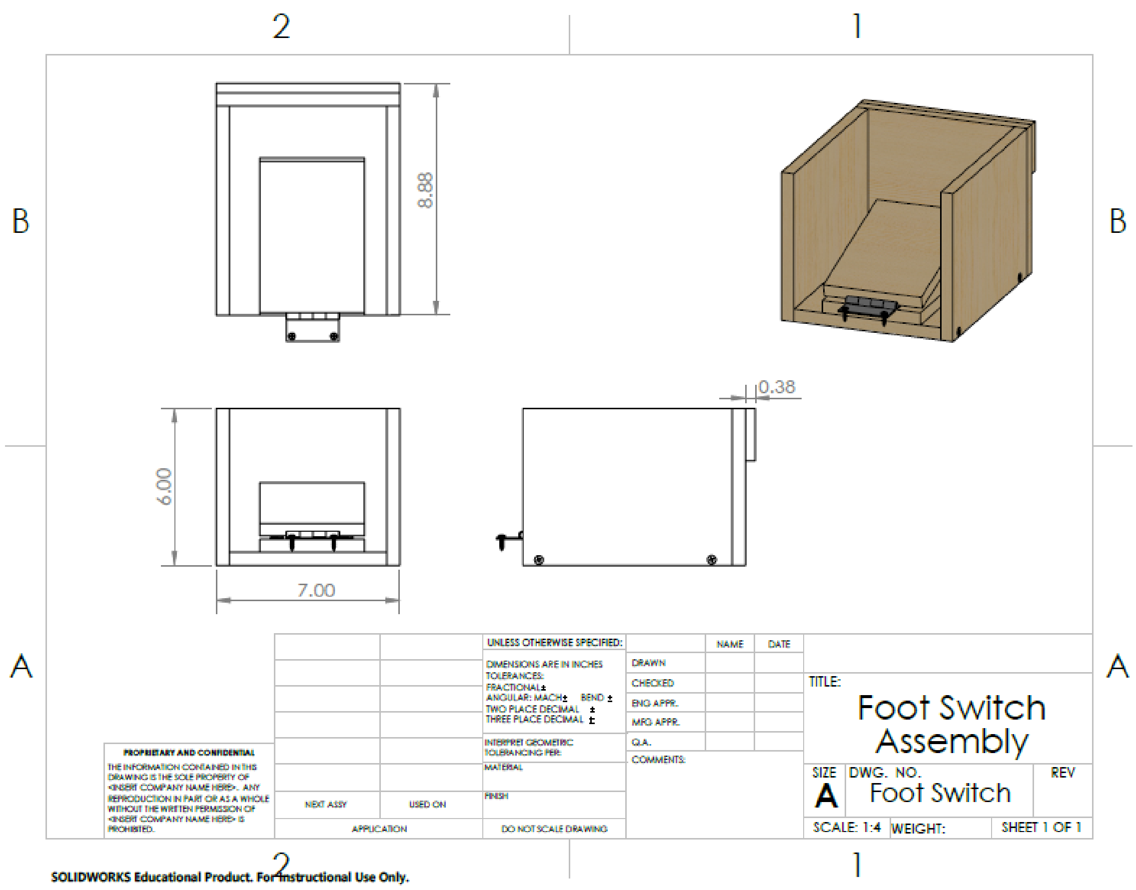

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Foot Switch Assembly
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SCALE: 1:4
WEIGHT:
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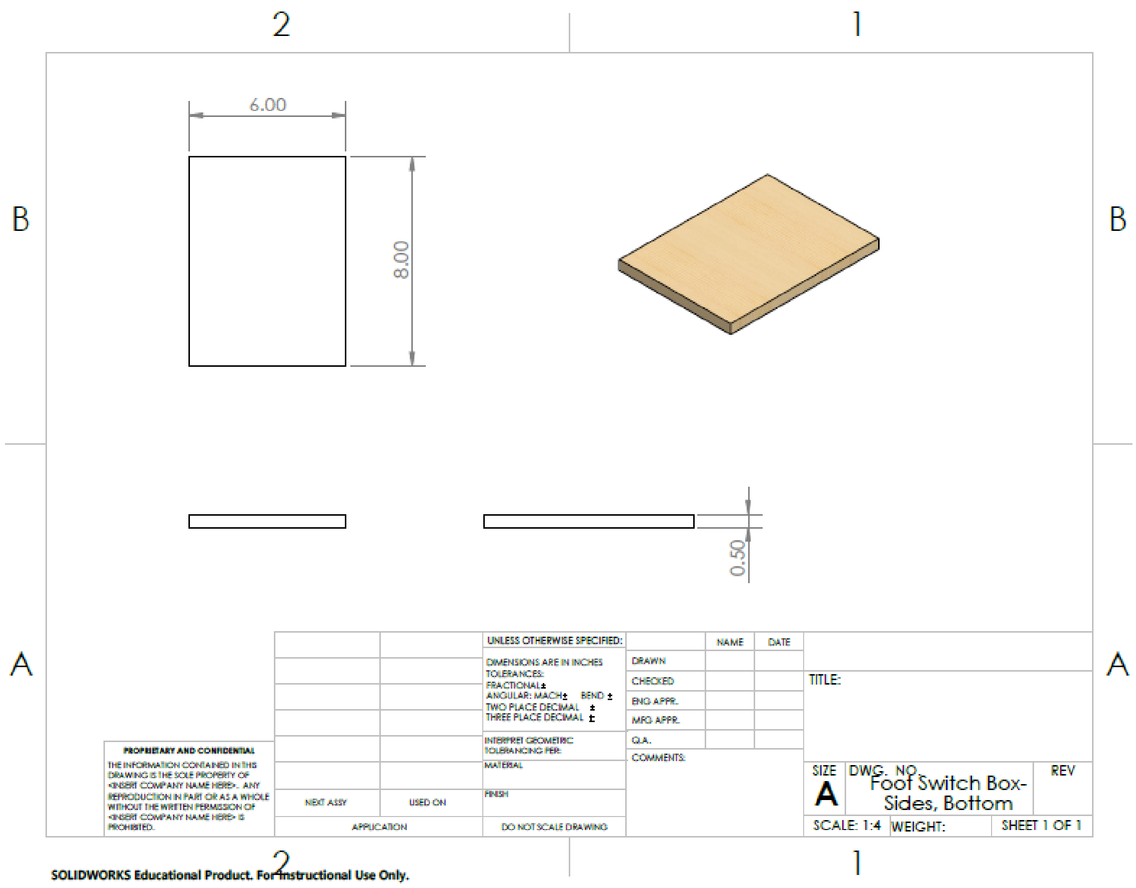

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Foot Switch Box-Sides, Bottom
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SCALE: 1:4
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
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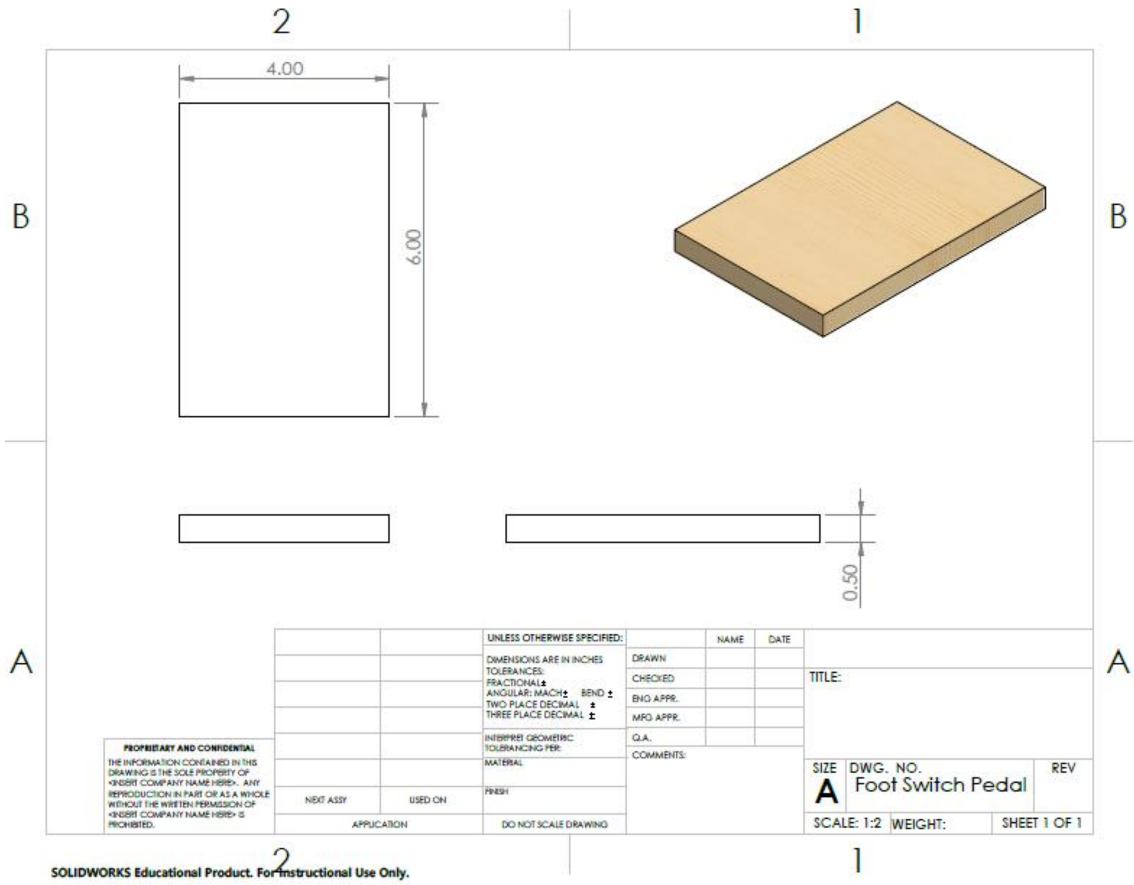
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Foot Switch Pedal
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SHEET 1 OF 1
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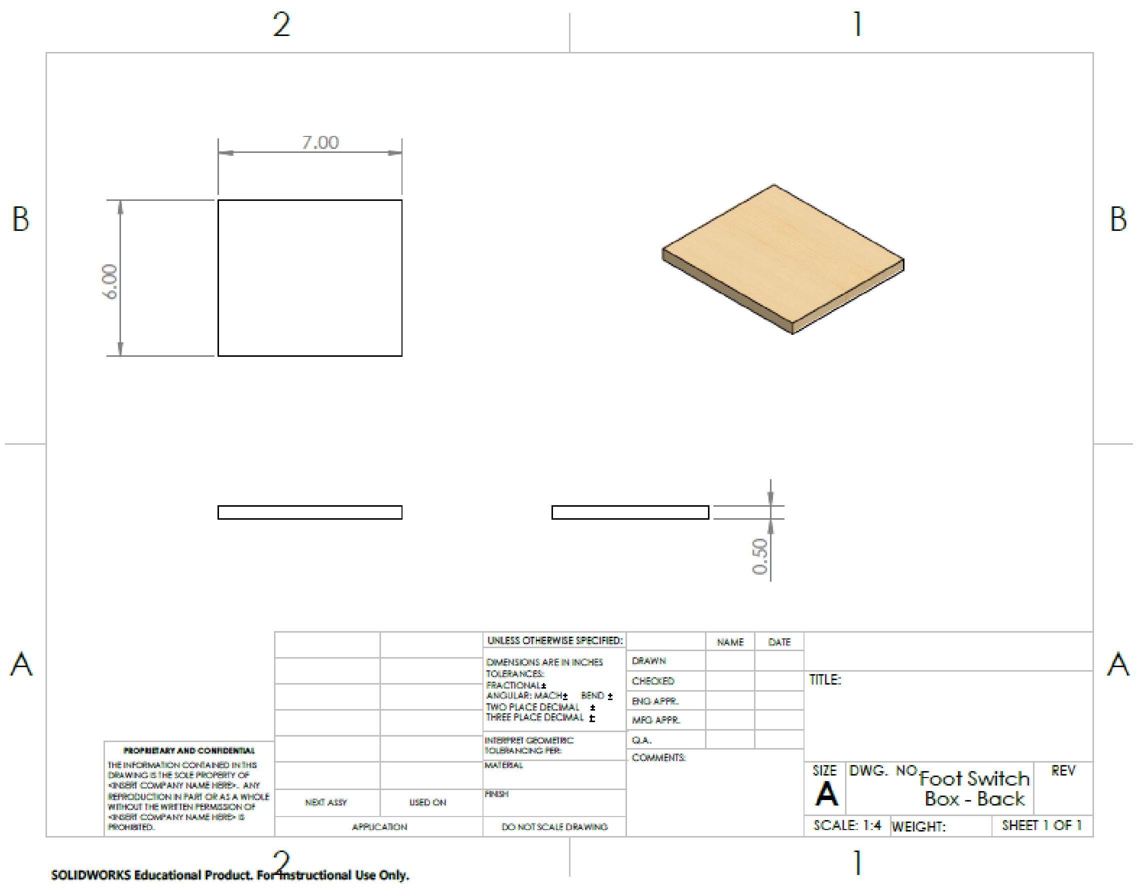
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Foot Switch Box - Back
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1
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USED ON
APPLICATION
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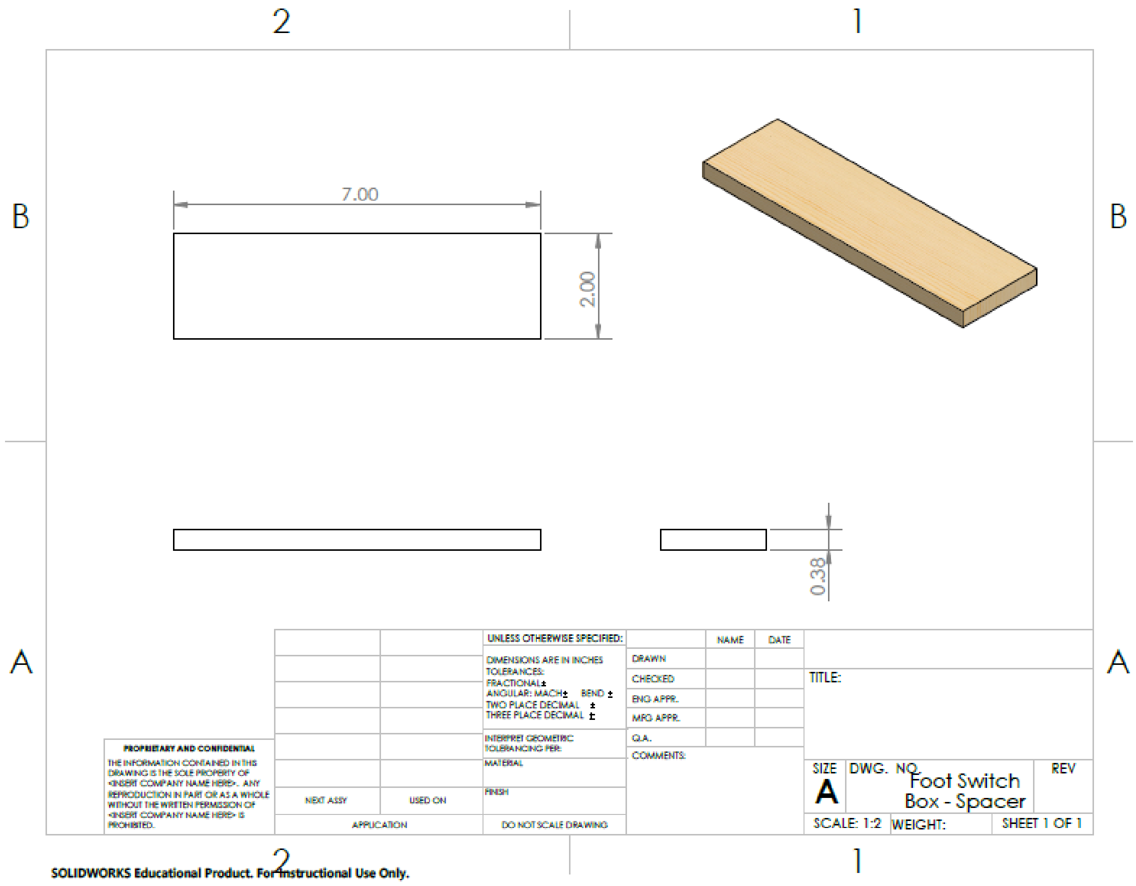



## 4.4 DESCRIPTION OF THE DESIGN RATIONALE

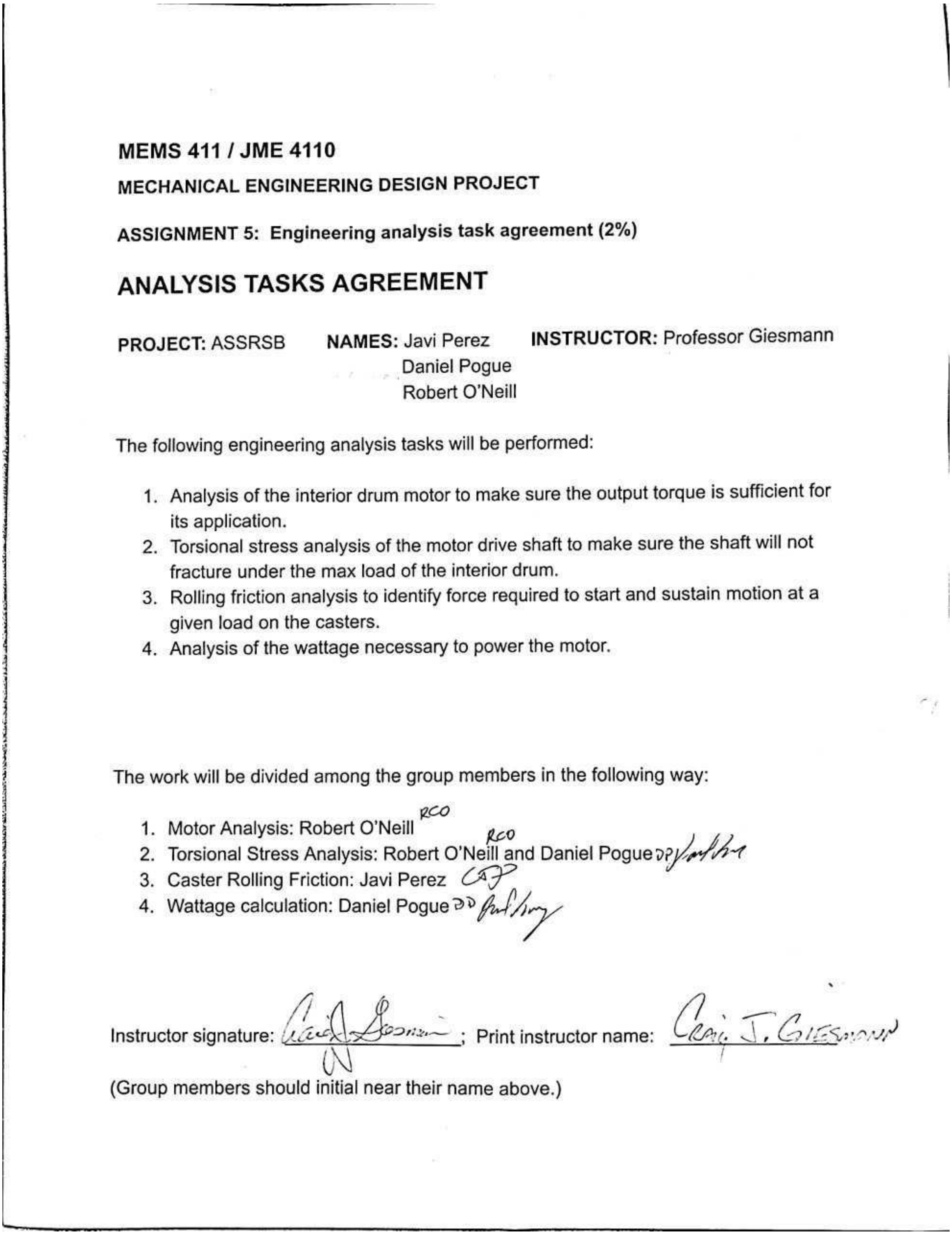
1. Metal Trash Barrel 55 Gallon - Chosen because it can be easily procured, durable, and large enough to hold estimated amount of collected recyclables. Used as the primary structure. All other components are housed inside and/or attached to the barrel.
2. Dolly - Made of ½" plywood that was scrounged. The diameter of the dolly was made smaller than the inside diameter of the metal barrel. Casters and sprocket are attached to the dolly which connects to the motor. Supports the plastic drum and allows rotation.
3. Motor - Geared to a lower speed with high torque and is small enough to fit into the drum housing used to rotate the Dolly. Analysis was made to ensure output torque of the motor was enough for the application.
4. Motor Bracket - Used to hold motor to the bottom of the barrel. Fabricated out of 0.061" thick stainless steel for durability and strength. Allowed for a low-profile bracket small enough so the dolly can rotate around the motor and bracket with enough clearance.
5. Swivel Caster - Swivel caster with 3" diameter wheels attached to the dolly giving use a 4" vertical clearance for the motor and bracket.
6. Plastic Drum - Modified an inexpensive trash can. Chose bin that had a smaller diameter than the metal barrel to allow for clearance of walls and electrical wiring.
7. Drum Dividers - Made of ⅛" thick 4'x4' hardboard sheet. Used to separate the plastic drum into four compartments. Chosen because it can easily be cut and is sturdy. Fabricated parts had to fit inside the plastic drum. Tolerances were high because pipe insulating foam was used to ensure a good fit inside the plastic drum.

8. Sprocket - Accepts the ⅜” diameter shaft from the motor. Easiest way to connect the motor shaft and the Dolly together. Had to be mounted to the bottom of the dolly so the plastic bin can seat properly.
9. Foot Switch & Box - Made of scrounged ½” plywood, springs, metal, and hinge. This is used by the operator to send a signal to the timer relay and motor for operation. Sized so that a user can easily press on it with shoes or boots on.
10. Timer Relay - Simple way to control the amount of time the motor is powered allowing for the bins to rotate properly.
11. AC Adapter - Has the desired output of 12VDC, 700mA. Used to power the motor and timer relay.

# 5 ENGINEERING ANALYSIS

## 5.1 ENGINEERING ANALYSIS PROPOSAL

### 5.1.1 Signed engineering analysis contract



MEMS 411 / JME 4110

MECHANICAL ENGINEERING DESIGN PROJECT

ASSIGNMENT 5: Engineering analysis task agreement (2%)

ANALYSIS TASKS AGREEMENT

PROJECT: ASSRSB

NAMES: Javi Perez
Daniel Pogue
Robert O'Neill

INSTRUCTOR: Professor Giesmann

The following engineering analysis tasks will be performed:

1. Analysis of the interior drum motor to make sure the output torque is sufficient for its application.
2. Torsional stress analysis of the motor drive shaft to make sure the shaft will not fracture under the max load of the interior drum.
3. Rolling friction analysis to identify force required to start and sustain motion at a given load on the casters.
4. Analysis of the wattage necessary to power the motor.

The work will be divided among the group members in the following way:

1. Motor Analysis: Robert O'Neill RCO
2. Torsional Stress Analysis: Robert O'Neill RCO and Daniel Pogue DP
3. Caster Rolling Friction: Javi Perez
4. Wattage calculation: Daniel Pogue DP

Instructor signature: ______; Print instructor name: Craig J. Giesmann

(Group members should initial near their name above.)

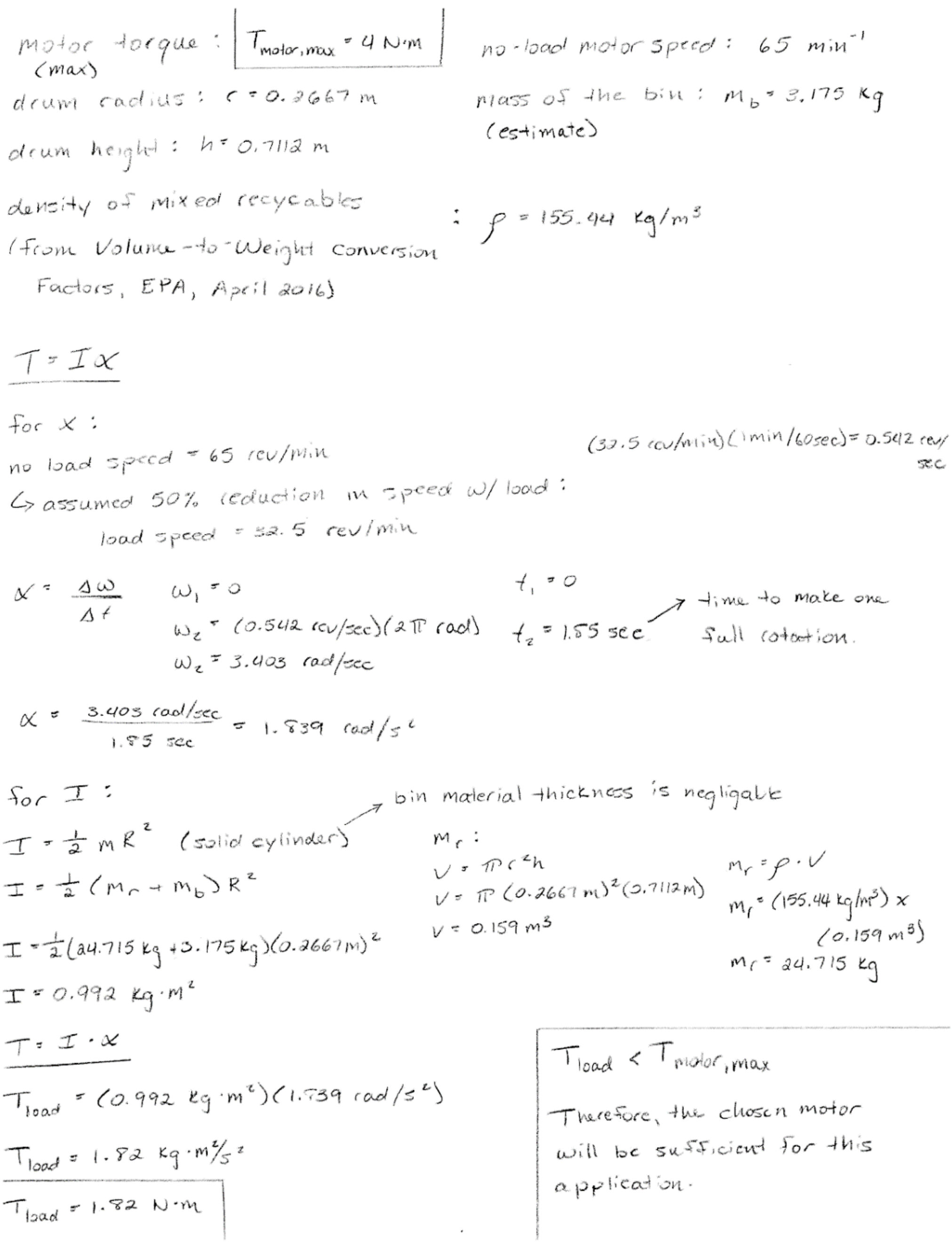
Figure 10: Engineering Analysis Agreement

## 5.2 ENGINEERING ANALYSIS RESULTS

### 5.2.1 Motivation

This analysis task was to measure the maximum torque needed to rotate the bin and compare it to the maximum torque output of the electric motor. This is an important thing to study at this time because we needed to verify if the motor, we chose would be sufficient. This analysis provided us enough information to purchase the motor for our prototype.

### 5.2.2 Summary statement of analysis done


motor torque (max): $T_{motor,max} = 4\ N{\cdot}m$

no-load motor speed: $65\ min^{-1}$

drum radius: $r = 0.2667\ m$

mass of the bin: $m_b = 3.175\ kg$ (estimate)

drum height: $h = 0.7112\ m$

density of mixed recycables (from Volume-to-Weight Conversion Factors, EPA, April 2016): $\rho = 155.44\ kg/m^3$

$T = I\alpha$

for $\alpha$:

no load speed = 65 rev/min

↳ assumed 50% reduction in speed w/ load:

load speed = 32.5 rev/min

$(32.5\ rev/min)(1\ min/60 sec) = 0.542\ rev/sec$

$\alpha = \frac{\Delta\omega}{\Delta t}$

$\omega_1 = 0$

$\omega_2 = (0.542\ rev/sec)(2\pi\ rad)$

$\omega_2 = 3.403\ rad/sec$

$t_1 = 0$

$t_2 = 1.85\ sec$ → time to make one full rotation.

$\alpha = \frac{3.403\ rad/sec}{1.85\ sec} = 1.839\ rad/s^2$

for $I$:

$I = \frac{1}{2} m R^2$ (solid cylinder) → bin material thickness is negligable

$I = \frac{1}{2}(m_r + m_b)R^2$

$m_r$:

$V = \pi r^2 h$

$V = \pi (0.2667\ m)^2 (0.7112\ m)$

$V = 0.159\ m^3$

$m_r = \rho \cdot V$

$m_r = (155.44\ kg/m^3) \times (0.159\ m^3)$

$m_r = 24.715\ kg$

$I = \frac{1}{2}(24.715\ kg + 3.175\ kg)(0.2667\ m)^2$

$I = 0.992\ kg{\cdot}m^2$

$T = I \cdot \alpha$

$T_{load} = (0.992\ kg{\cdot}m^2)(1.839\ rad/s^2)$

$T_{load} = 1.82\ kg{\cdot}m^2/s^2$

$T_{load} = 1.82\ N{\cdot}m$

$T_{load} < T_{motor,max}$

Therefore, the chosen motor will be sufficient for this application.

**Figure 11: Motor Torque Analysis Results**

### 5.2.3 Methodology

The analysis was done using values derived from the cut sheet of the motor. The values used were the maximum motor torque and the no load speed of the motor. Using the no load speed, an assumption was made that the speed of the motor would be reduced by 50% to account for an added load. This was done to make sure that the motor met our demands. Also, the average density of mixed recyclable materials was found to calculate the mass of the rotating bin at maximum capacity. These values were plugged into various equations (see above) to derive the torque needed to rotate the drum.

### 5.2.4 Results

From this analysis, it was determined that the motor would be sufficient for this application. This makes sense from the assumptions made and the factory performance of the motor.

### 5.2.5 Significance

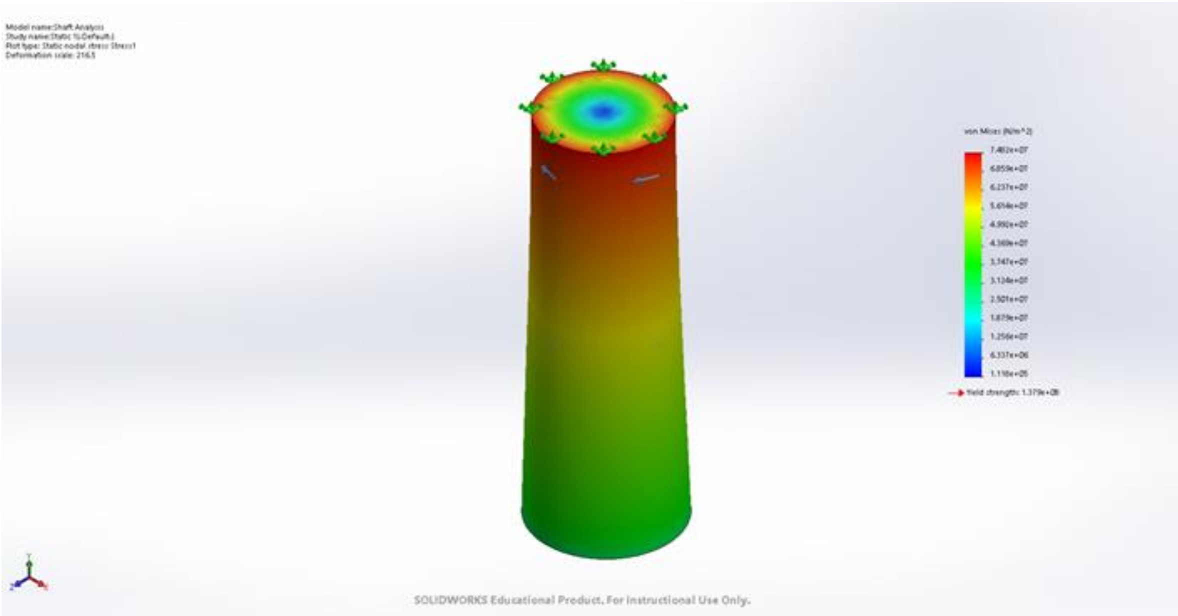
These results influence the final prototype because this is the motor, we will be using for it. The dimensions that will be affected are the dimensions of the motor mount within the outer drum. The materials chosen for the mount will not change, since they were and will be majority steel.

### 5.2.6 Motivation

This analysis task was to determine if the motor shaft can withstand the applied torque generated from the mass of the attached drum. This in an important thing to study at this time because the motor shaft will experience the most torsional stress of all the components within the system. This analysis provided us enough information to purchase the motor for our prototype.

### 5.2.7 Summary statement of analysis done

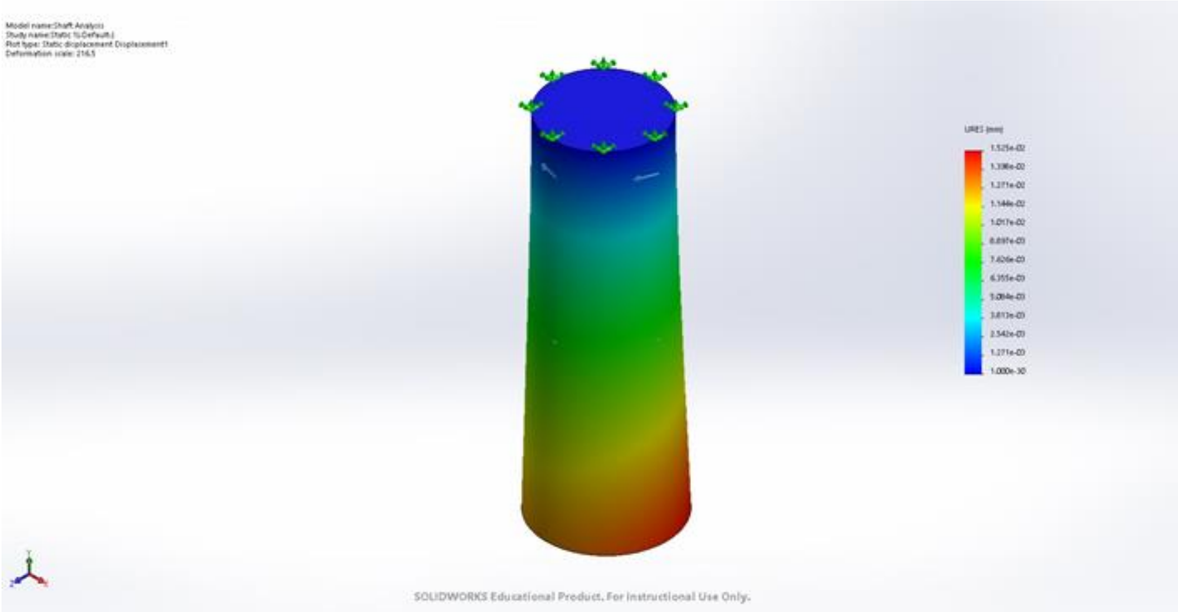
| | | | |
|---|---|---|---|
| **Stress1** | **VON: von Mises Stress** | **1.118e+05 N/m^2**<br>**Node: 3399** | **7.482e+07 N/m^2**<br>**Node: 8** |




Shaft Analysis-Static 1-Stress-Stress1

**Figure 12: Shaft Analysis - von Mises Stress**

| Displacement1 | URES:   Resultant Displacement | 0.000e+00 mm<br>Node: 1 | 1.525e-02 mm<br>Node: 243 |
|---|---|---|---|




Shaft Analysis-Static 1-Displacement-Displacement1

**Figure 13: Shaft Analysis - Displacement**

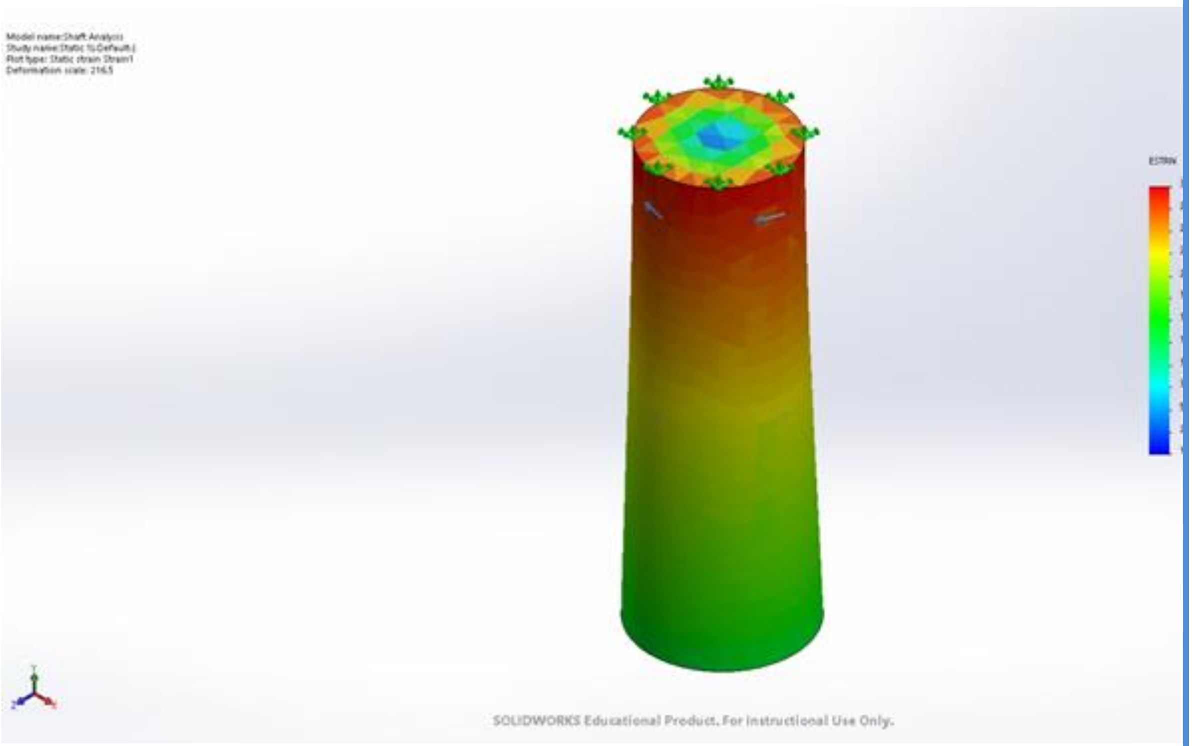
| Strain1 | ESTRN: Equivalent Strain | 1.625e-06<br>Element: 1450 | 3.134e-04<br>Element: 7173 |
|---|---|---|---|
| <br>Shaft Analysis-Static 1-Strain-Strain1 | | | |

Figure 14: Shaft Analysis - Strain

### 5.2.8 Methodology

Analysis was completed using a SolidWorks model of the motor shaft. Stress, strain, and displacement studies were conducted. Material was assumed to be AISI 316 Annealed Stainless Steel. A max torsional load of 4 N/m was used in the study because that is the max torque of the motor.

### 5.2.9 Results

Results were as expected. The max shaft stress and strain occurs near the fixed end and the max displacement occurs furthest away from the fixed end. The shaft will not fail at the max torque of 4 N/m.

### 5.2.10 Significance

The motor was selected to be powerful enough to rotate the bins on the casters.

### 5.2.11 Motivation

The design of the ASSRSB relies on three swivel casters being able to rotate by an electric motor. The force required to initiate and sustain movement is dependent on the rolling resistive force of the casters and the normal force applied. It is important to understand this in order to predict the max weight capacity of the ASSRSB and is important to help choose an appropriate motor size for the design.

### 5.2.12 Summary statement of analysis done

To calculate rolling resistance [lbf] the following equation is used [1].

$$F = \mu(w/r) \tag{1}$$

Where $\mu$ is the coefficient of rolling friction (between the wheel material and floor surface) [in], $w$ is the normal force [lbf], and r is the radius of the wheel.

### 5.2.13 Methodology

Assumptions:
$\mu$ = .05 in (plastic or hard polyurethane wheel on smooth steel)
Neglecting air resistance, slipping, bearing friction, floor or ground deflection.
The force to initiate motion is twice the sustaining force [2].

Example:

$F = \mu(w/r) = .05\ in\ (100\ lbf\ /\ 1.5\ in) = 3.33\ lbf$ to sustain motion.

6.66 lbf is required to initiate movement assuming it takes twice as much force as sustaining.

### 5.2.14 Results

Below is a plot showing force required to overcome rolling friction vs load.

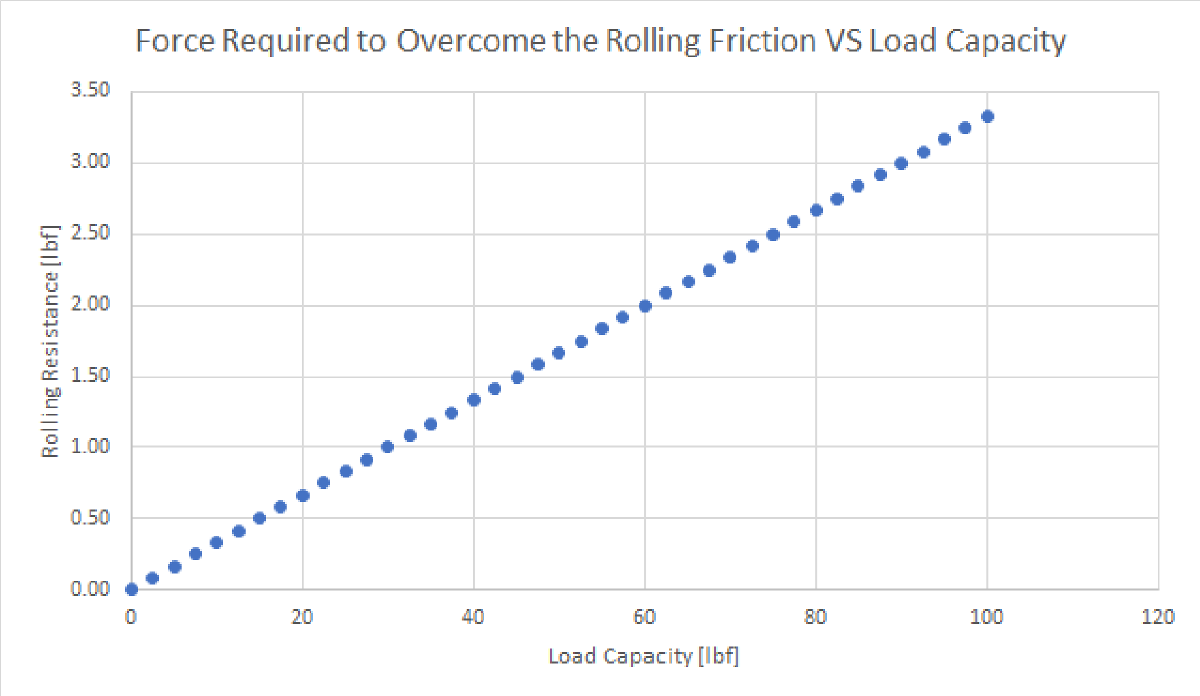


Figure 15: Frictional Analysis Results

### 5.2.15 Significance

With this data we can predict the maximum load our selected motor can be expected to perform at.

### 5.2.16 Motivation

Take the given maximum voltage and current and calculate the wattage needed to supply. The time it takes the motor to switch between the receptacles at the maximum RPM and at the load reduced RPM. These calculations help our group understand the equipment necessary to carry out construction of the ASSRSB, as well as the time delay for the receptacle rotation.

### 5.2.17 Summary statement of analysis done

| No Load Wattage and Time Calculations | | | |
|---|---|---|---|
| RPM | Revolutions Needed | Seconds | New RPS |
| 65 | 0.25 | 60 | 4.333333 |
| With Load Reduction | Needed | Seconds | New RPS |
| 32.5 | 0.25 | 60 | 2.166667 |

| Voltage | Current | Wattage |
|---|---|---|
| 24 | 4 | 96 |
| 12 | 2 | 24 |
| 5 | 0.833333 | 4.166667 |

| Equation | |
|---|---|
| Power | V*I |

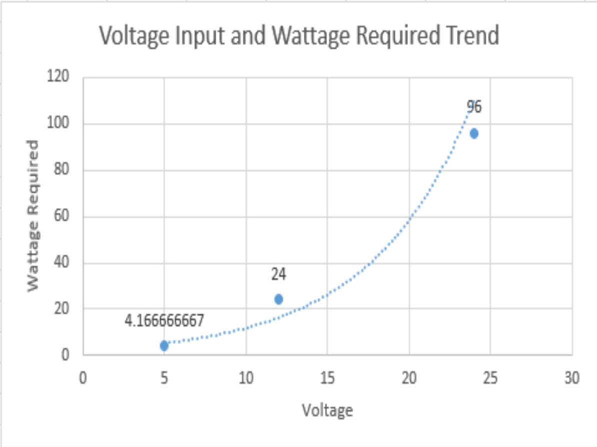



**Figure 16: Power Requirement Analysis**

### 5.2.18 Methodology

Using common engineering and physics equations I calculated both the wattage requirement and the revolutions every second (at both the reduced speed and at the maximum speed). There was no need for any test rigging but since items have not come in, additional testing will be required to compare against the theoretical data above. The above data was hand calculated and then later formatted properly in Microsoft Excel software.

### 5.2.19 Results

The results showed that every quarter of a second the motor completes a quarter rotation and that as the voltage increased the wattage also increased. Both results make sense with the theory behind converting the rpm to rps with an adjustable drop added for the force on the motor and the electrical theory behind wattage calculations given the current and the voltage.

### 5.2.20 Significance

The calculations affect how the ASSRSB will be wired and the type of outlets necessary for operation (in this case a normal 120V outlet) as well as the timing in which our relay switches will need to operate to achieve the accurate bin location. The dimensions stay the same for the ASSRSB and a timer relay will now be used in place of an Arduino and breadboard set up.

# 6 RISK ASSESSMENT

## 6.1 RISK IDENTIFICATION

The project had multiple risks that would limit its ability to function property during operation. The first risk that was identified was the ability to locate and utilize sensors that would be able to identify specific materials as they entered the bin. Without the sensors, the device would be unable to differentiate between materials and hinder the complete automation behind the sorting process. The second risk was the size and power of the electric motor to rotate the internal bin of the system. If the motor was too large, it would take up too much space within the bin, limiting the number of recyclables able to fit within. Also, if the motor did not have enough power, it would be unable to rotate the bin when it's at maximum capacity. The third risk was the amount of rolling friction experienced by the casters which supported most of the weight of the internal bin. If the casters experienced too much friction, it would cause more stress on the motor, reducing its efficiency and possibly its life span.

## 6.2 RISK ANALYSIS

The risk analysis of the design was done through various calculations, SolidWorks simulations, and deliberate research into the capabilities and cost of various components. In determining if it was possible to use sensors that would be able to identify and differentiate between specific types of recyclables (i.e. glass, paper, plastic, and metal), a suitable solution within the parameters of the budget was not found. With that, a different approach was taken for the design, withdrawing from autonomously sorting recyclable and implement the sorting through the user. For the motor, the theoretical torque needed to rotate the bin was calculated and compared to the torque output of the electric motor. For the rolling friction experienced by the casters, the theoretical amount of force needed to overcome the frictional forces experienced by the casters was calculated. Also, through testing, it was discovered that the casters would be able to rotate without frictional impedances.

## 6.3 RISK PRIORITIZATION

Risk for our project was prioritized based on how they would influence the overall performance measure of the design. Specifically, what risk would be the largest hindrance to the successful functioning of the design. Once it was determined that the design would not be fully autonomous, the rotation and switching mechanisms became the priority of the project. Second to the operational components, was the structural integrity of the moving components within the bin.

# 7 CODES AND STANDARDS

## 7.1 IDENTIFICATION

I. UL 1004-1 Standard for Rotating Electrical Machines - General Requirements

II. OSHA Standard 29 CFR 1910 Subpart O: Machinery and Machine Guarding

III. NFPA 70 - National Electrical Code

IV. ASTM E3159 – 18

## 7.2 JUSTIFICATION

I. This Standard is used to evaluate motors intended to be field installed. Covers Ventilation Openings, Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, etc.

II. The inner bin rotates inside the outer drum causing a potential pinch/shear hazard.

III. Electric motor will require additional wiring and the device will be using a standard outlet, in a given facility, for power.

IV. This standard is used to predict the reliability of survival at specific times or for specific usage cycles for simple components, devices, assemblies, processes, and systems. This standard will help us with quality control for our system.

## 7.3 DESIGN CONSTRAINTS

I. The inner drum rotation must be completely enclosed.

II. Motor shaft and rotating parts have to be shielded from users for safety.

III. The constraint is the wiring which requires, no exposure, enough insulation, and efficiency.

IV. All fittings, hardware, “welds” and will need to withstand significant timed operations.

## 7.4 SIGNIFICANCE

I. Will not have any large openings and will need to include safety labels. This will not affect our material selection or dimensioning.

II. Used a larger outer drum that could accommodate the inner mechanisms of the design.

III. Our system requires heavy use of electronics to properly operate. As well as being powered by an electrical outlet so understanding electrical safety is a must.

IV. Improves the life expectancy of our product and gives a clear idea of the life cycle of the product.

# 8 WORKING PROTOTYPE

## 8.1 PROTOTYPE PHOTOS

Figure 17: ASSRSB Front View

Figure 18: ASSRSB Arial View

## 8.2 WORKING PROTOTYPE VIDEO

https://www.youtube.com/watch?v=KPaDZ329d9w

## 8.3 PROTOTYPE COMPONENTS

1. *Motor with Mounting Bracket:*

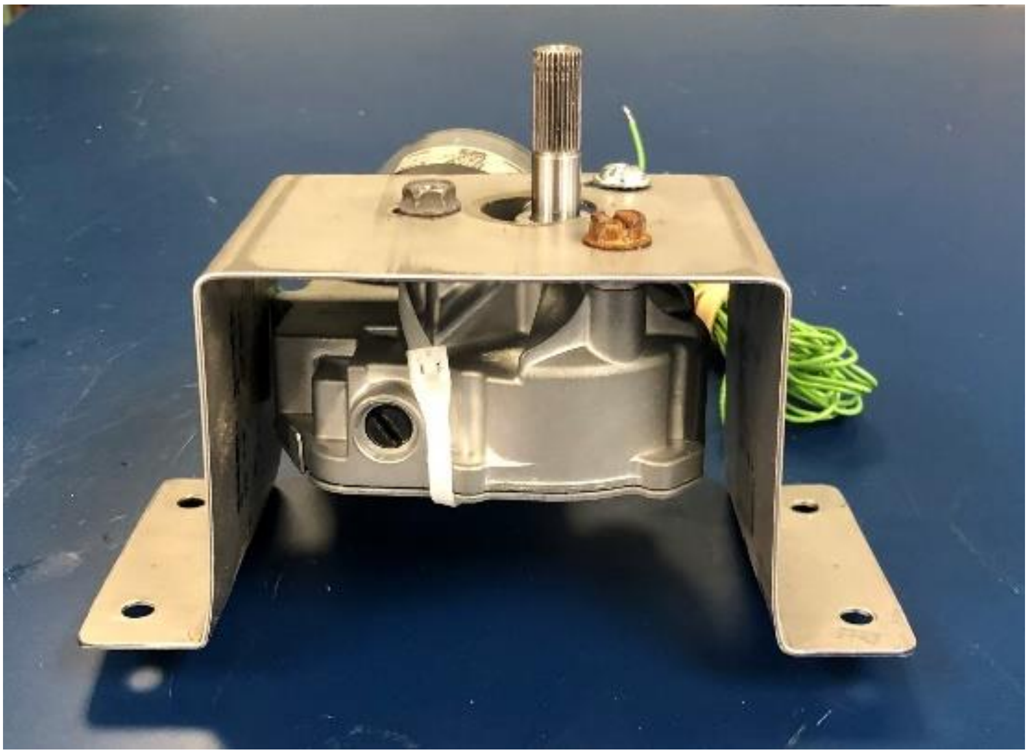


**Figure 19: Motor with Mounting Bracket Side View**

**Figure 20: Motor with Mounting Bracket Top View**

The Nidec motor is attached to a bracket using three M6 x ½” self-tapping screws. The steel bracket was fabricated specifically for this application for the shaft height to align with the sprocket on the rotating platform. The motor itself was rewired to bypass the switch capability designed by the manufacturer, which allows the timer relay and foot switch to control its rotation.

2. *Rotating Platform:*

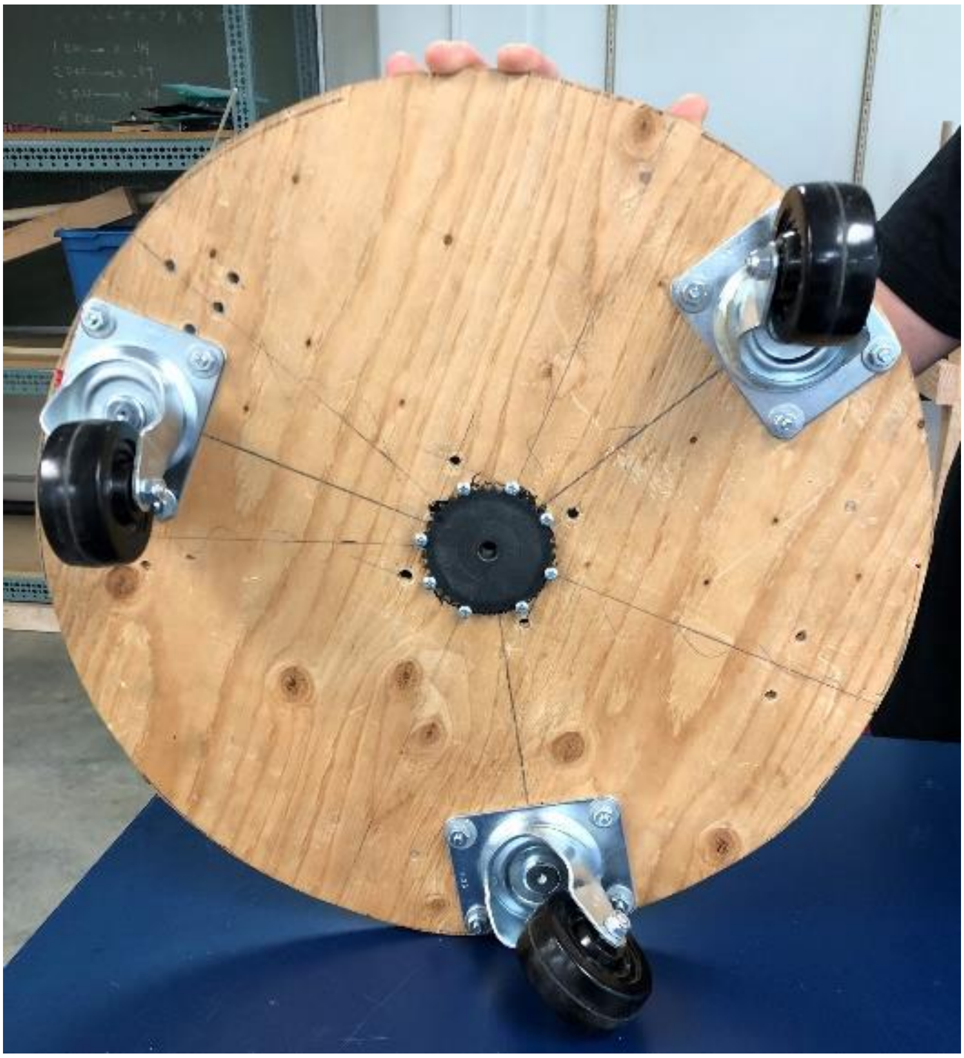


**Figure 21: Rotating Platform Bottom View**

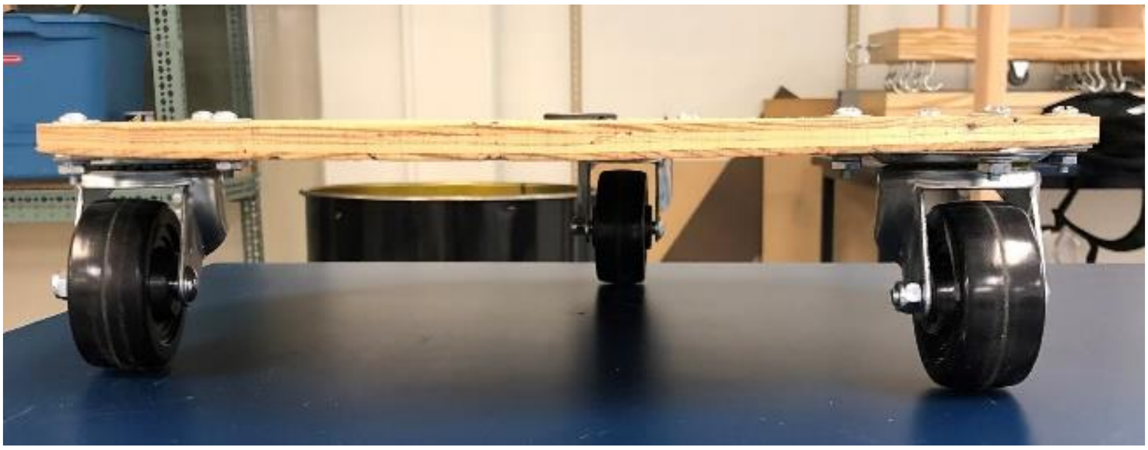


**Figure 22: Rotating Platform Side View**

The rotating platform is repurposed, pre-cut ⅜” plywood. Three 3” wheel casters are evenly spaced around the outside edge and fastened using bolts, washers, and nuts. The sprocket in the center is fastened to the wood using eight screws. Also, the sprocket is attached to the shaft of the motor using set screws that come with the sprocket.

3. *Rotation Activation Foot Switch:*

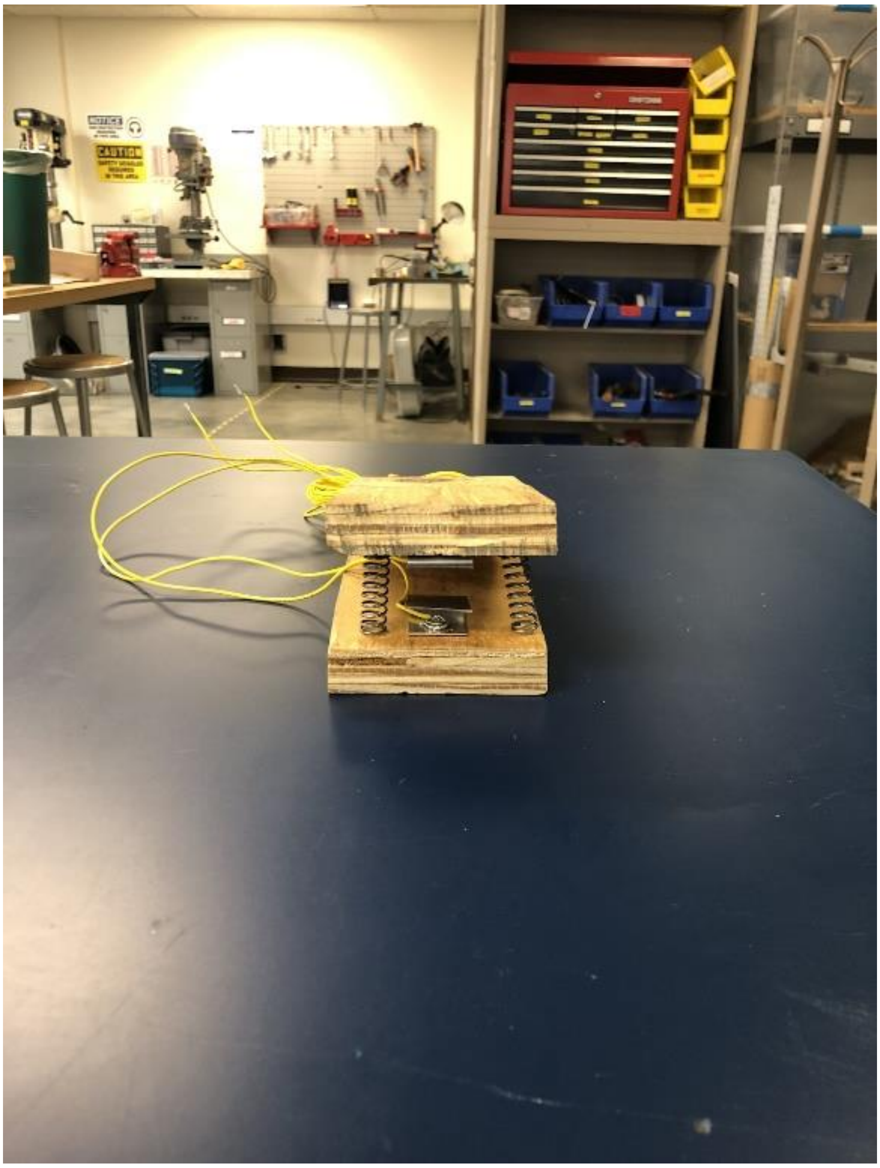


**Figure 23: Foot Switch Front View**

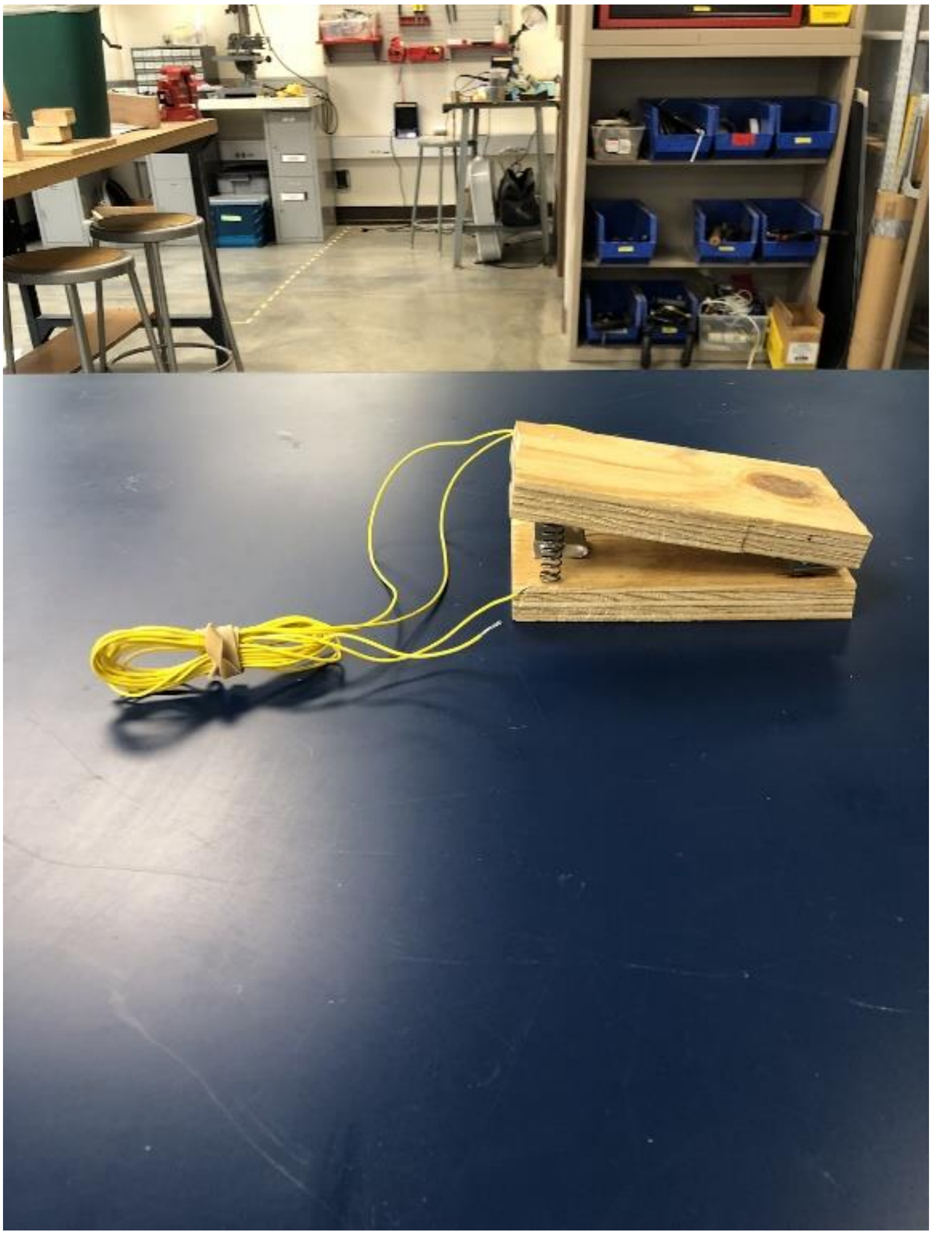


**Figure 24: Foot Switch Side View**

The foot switch was constructed out of two pieces of scrap plywood, two springs, one hinge, bent contact metal, wire, and wood screws. The springs allow the top plate of the switch to be pressed down, to make a connection between the two pieces of metal. When the connection is made, the timer relay is switched on and it subsequently sends power to the motor for rotation. The switch was constructed with durability in mind, due to the force applied to it from the user's foot.

4. *Motor Rotation Timer Relay:*

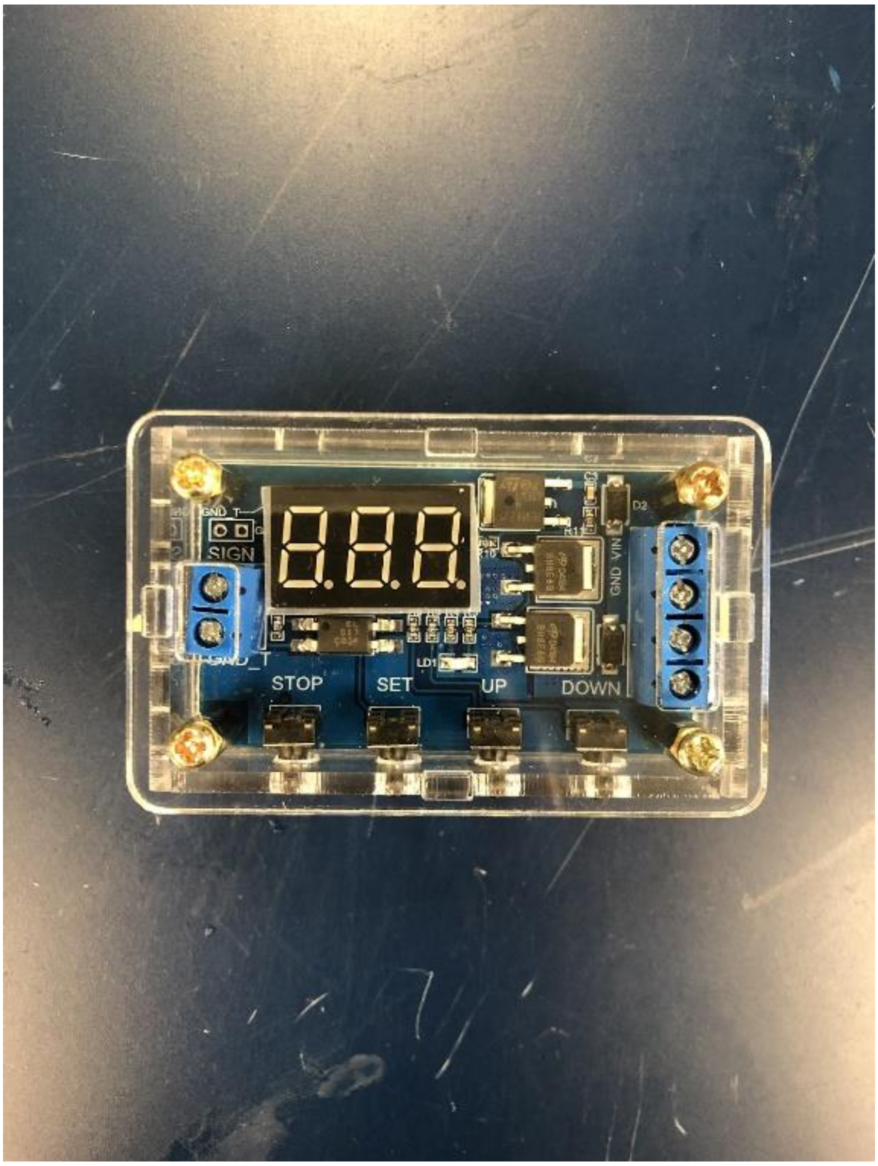


**Figure 25: Timer Relay Top View**

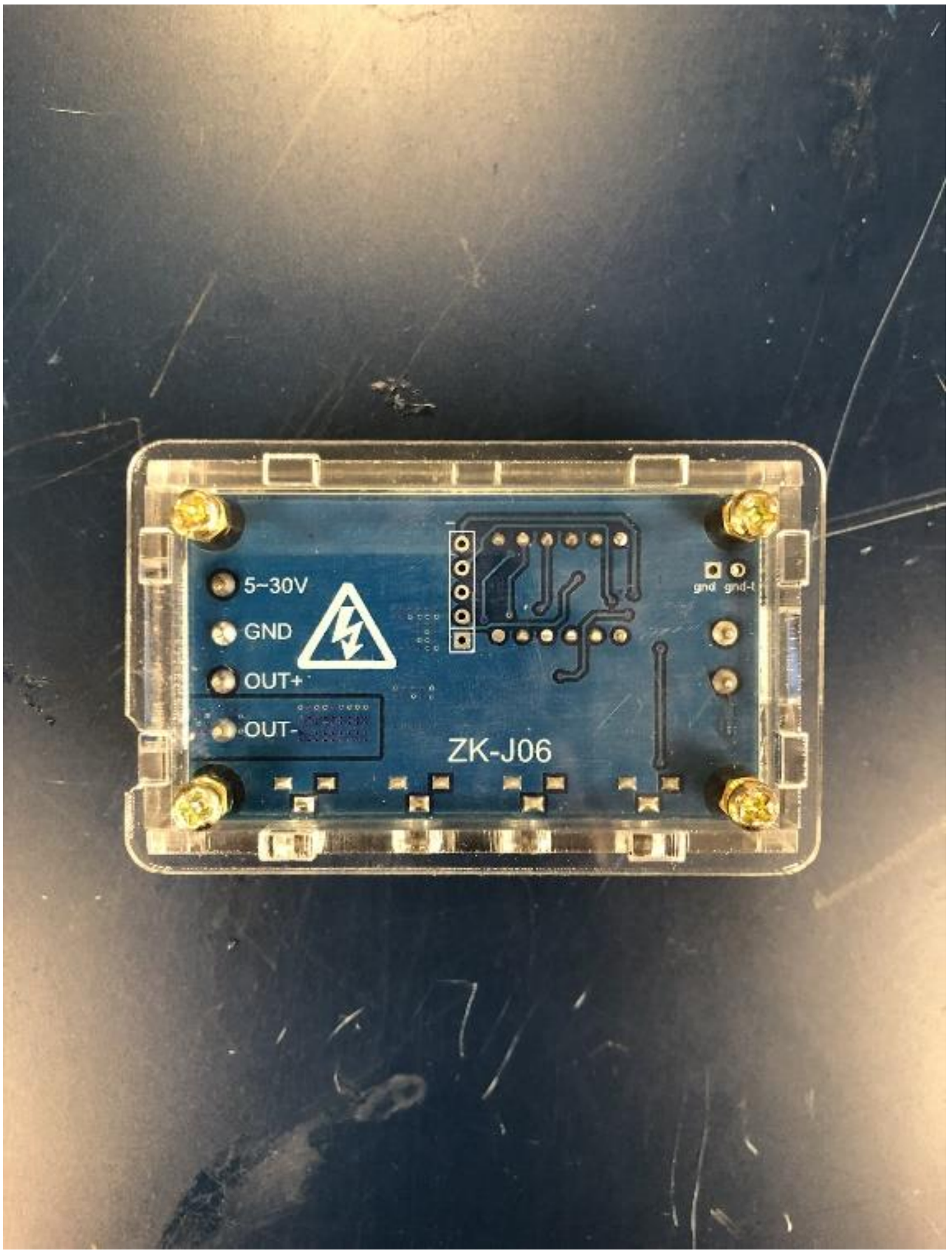


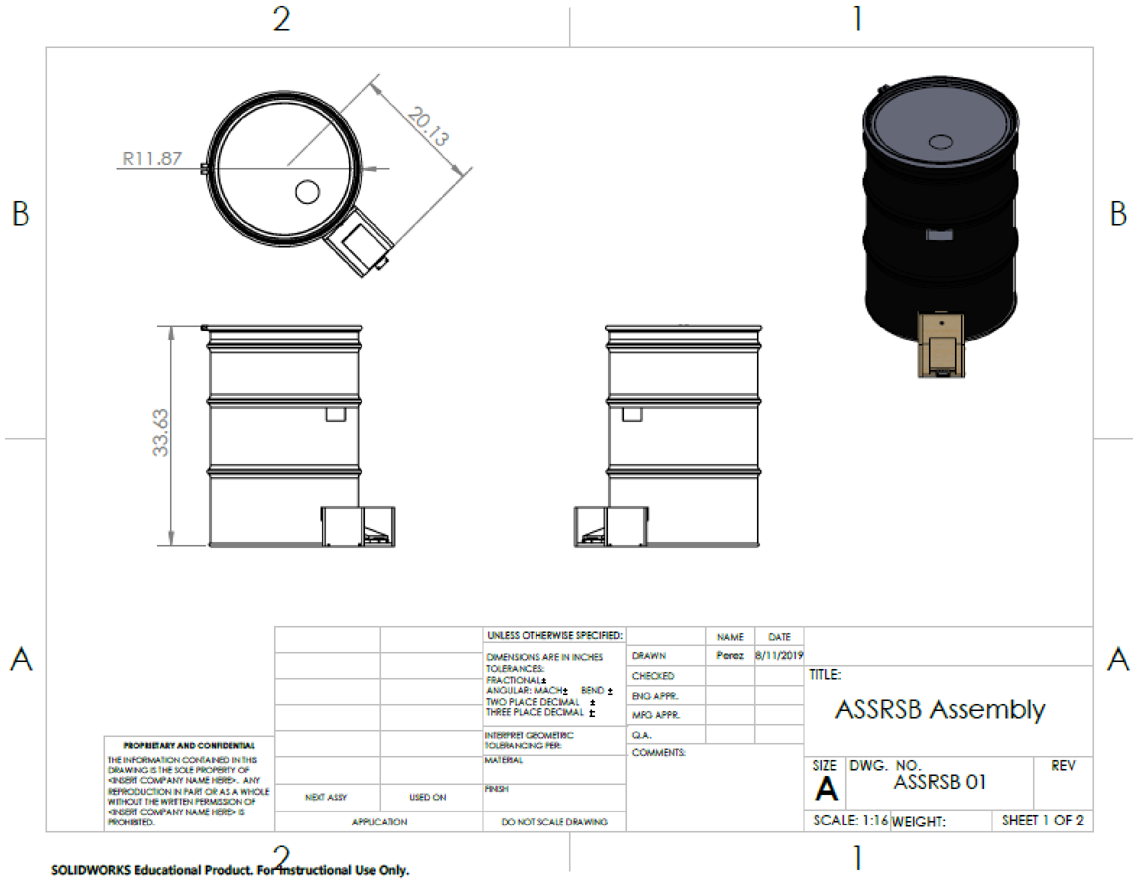
**Figure 26: Timer Relay Bottom View**

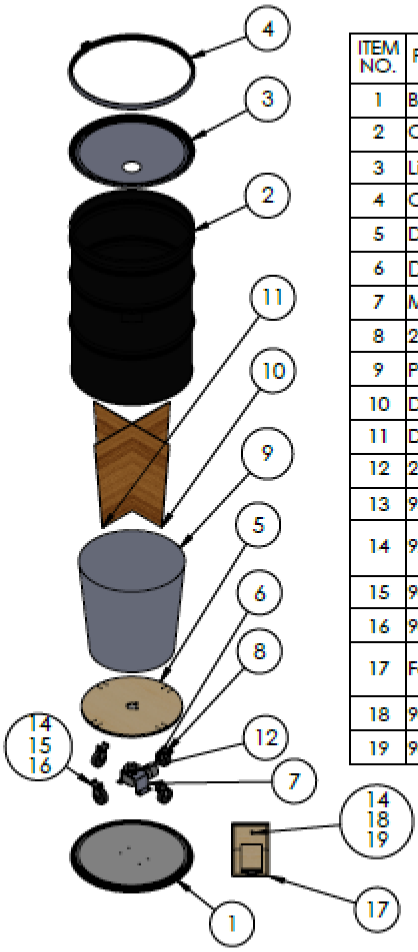
This timer relay was chosen to conveniently adjust and regulate the rotational speed of the motor to the tenth of a second. It has four buttons to adjust the type of operation and the operational time. The 12V DC power from the wall AC to DC rectifier was wired directly to the relay. The rectifier drops the residential voltage, from the wall outlet, at 120V to 12V. Also, the footswitch and the motor were wired through it as well.

# 9 DESIGN DOCUMENTATION

## 9.1 FINAL DRAWINGS AND DOCUMENTATION

### 9.1.1 Engineering Drawings






| ITEM NO. | PART NUMBER | DESCRIPTION | Exploded View/QTY. |
|---|---|---|---|
| 1 | Bottom | | 1 |
| 2 | Cylinder | | 1 |
| 3 | Lid | | 1 |
| 4 | Clamp | | 1 |
| 5 | Dolly | | 1 |
| 6 | DCK31 | Nidec Motor | 1 |
| 7 | Motor Bracket | Bracket | 1 |
| 8 | 22785T43 | Swivel Caster | 4 |
| 9 | Plastic Drum | | 1 |
| 10 | Drum Divider 2 | | 1 |
| 11 | Drum Divider 1 | | 1 |
| 12 | 2737T261 | Sprocket | 1 |
| 13 | 93360A220 | Wood Screw | 7 |
| 14 | 92141A011 | Washer (Multiple Locations) | 26 |
| 15 | 90272A198 | Machine Screw | 20 |
| 16 | 90480A009 | Hex Nut | 20 |
| 17 | Foot Switch | Foot Switch Assembly | 1 |
| 18 | 90272A836 | Machine Screw | 1 |
| 19 | 90480A195 | Hex Nut | 1 |

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DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
MATERIAL
FINISH
NEXT ASSY | USED ON
APPLICATION
DO NOT SCALE DRAWING

NAME | DATE
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CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:

SIZE A | DWG. NO. ASSRSB Exploded | REV.
SCALE: 1:14 | WEIGHT: | SHEET 1 OF 1

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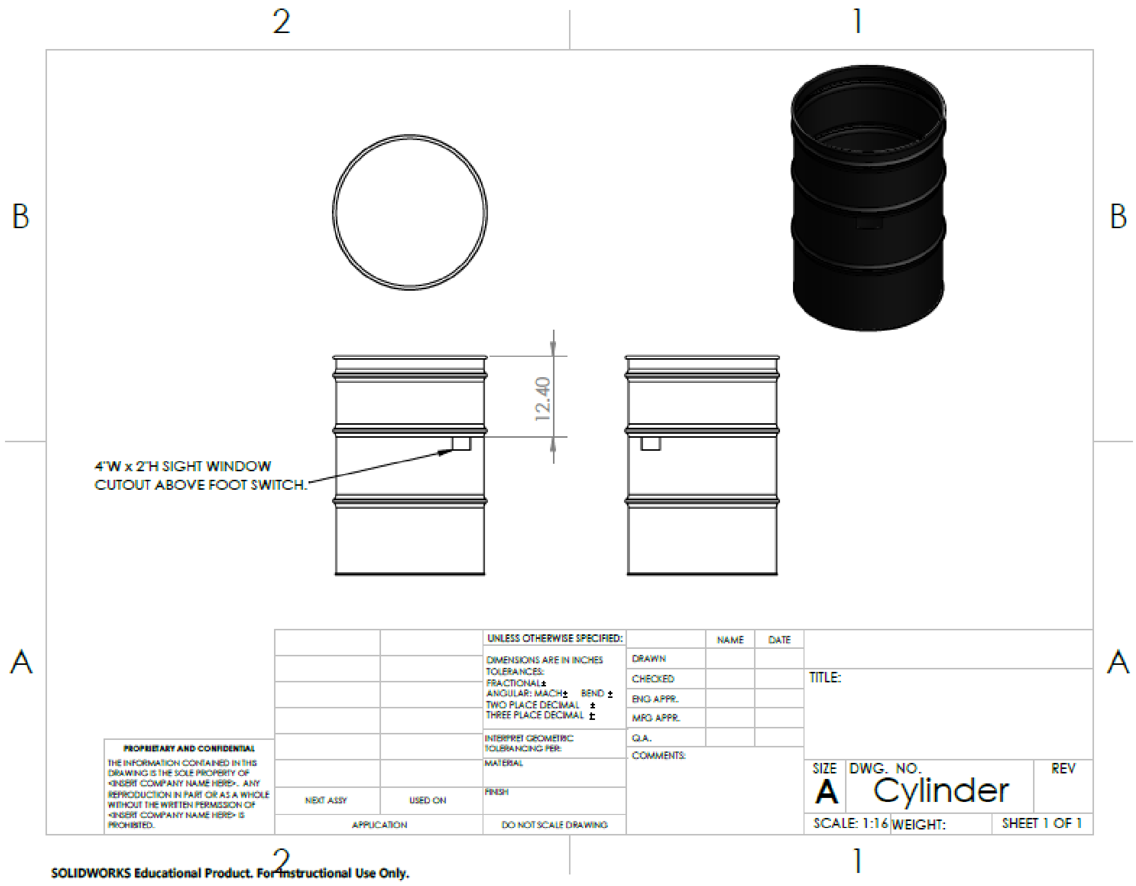

12.40
4"W x 2"H SIGHT WINDOW
CUTOUT ABOVE FOOT SWITCH.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±
ANGULAR: MACH± BEND ±
TWO PLACE DECIMAL ±
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SIZE
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A
Cylinder
SCALE: 1:16
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
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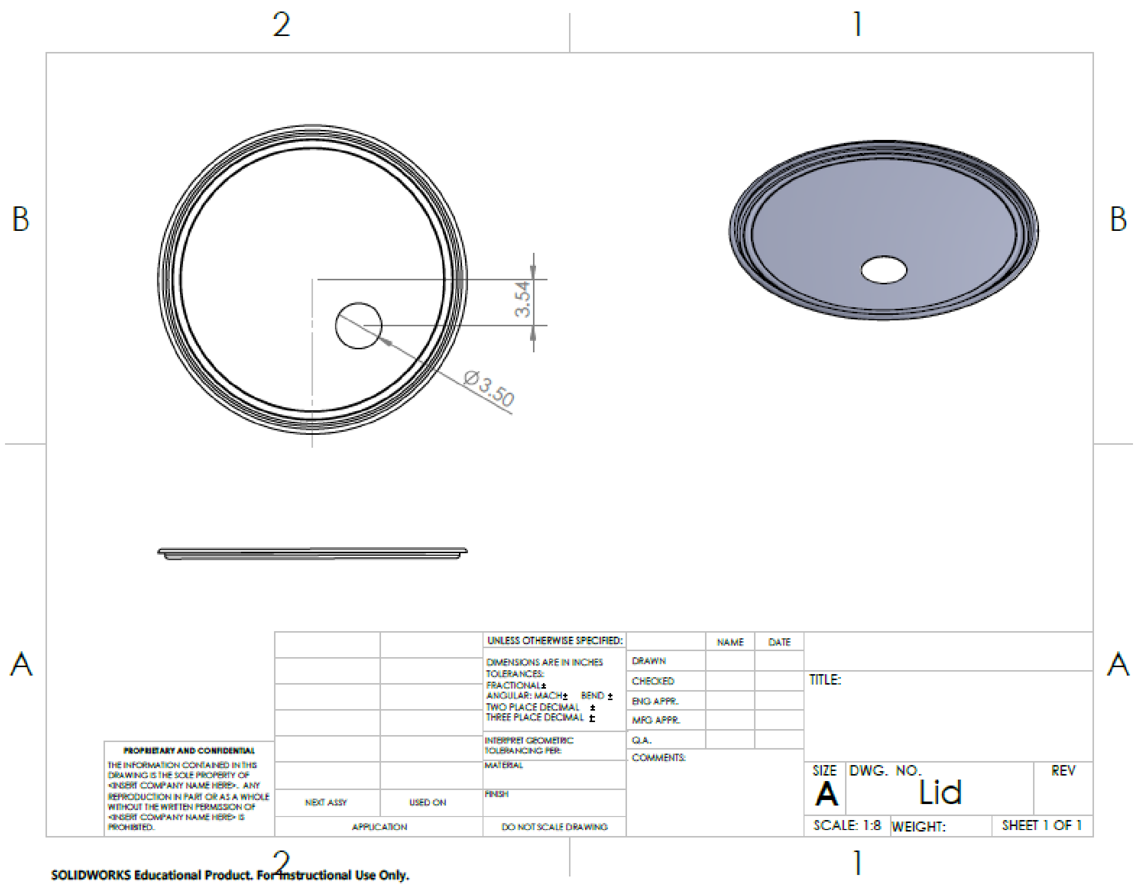

3.54
Ø3.50
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PROPRIETARY AND CONFIDENTIAL
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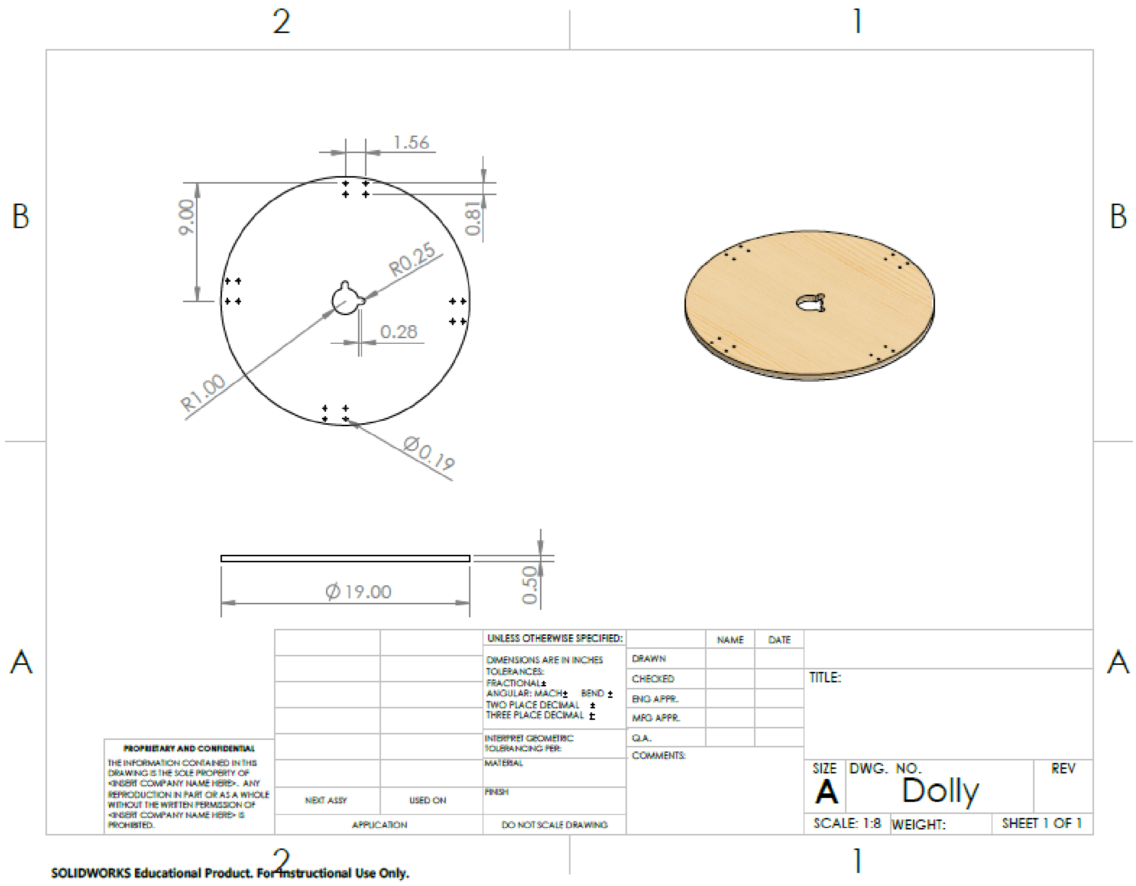

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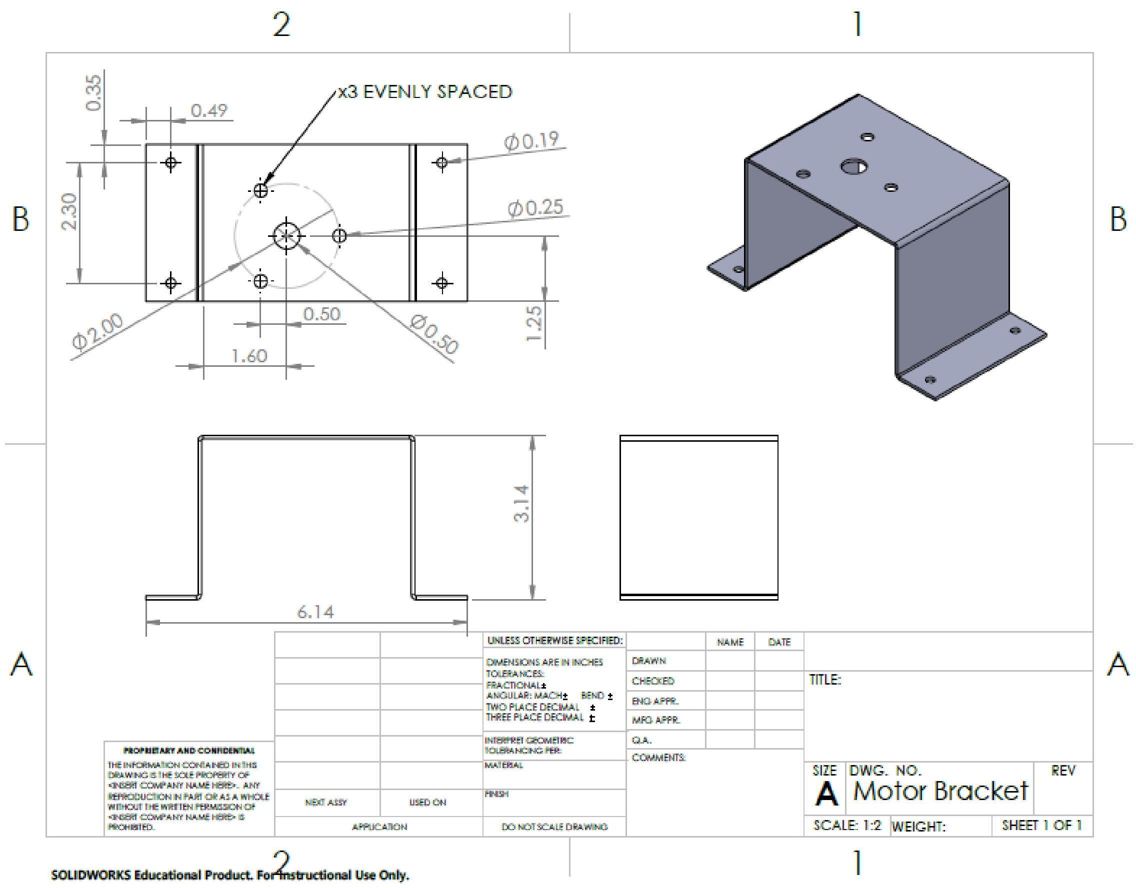

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Motor Bracket
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SHEET 1 OF 1
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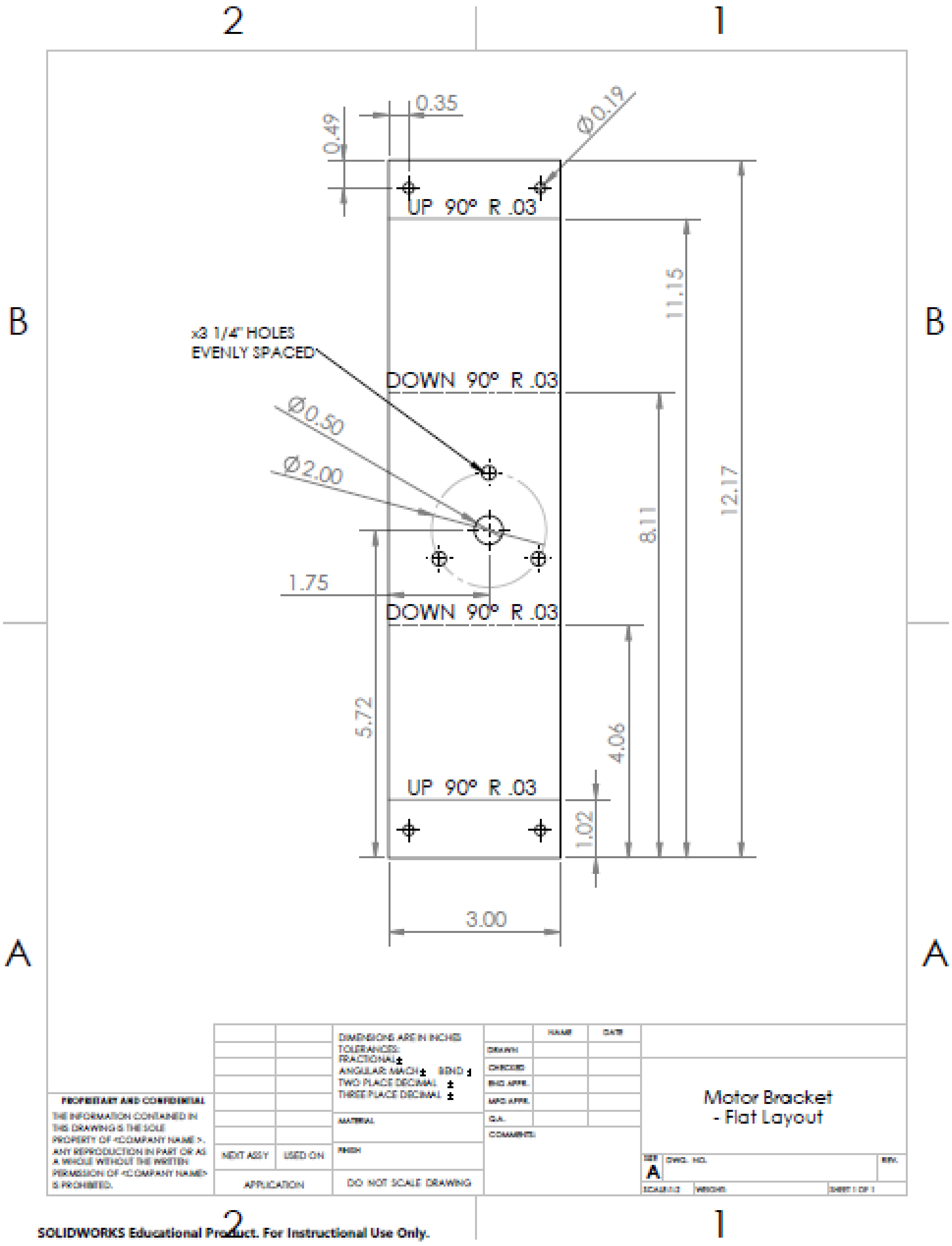
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Ø0.19
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UP 90° R .03
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x3 1/4" HOLES
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Motor Bracket
- Flat Layout
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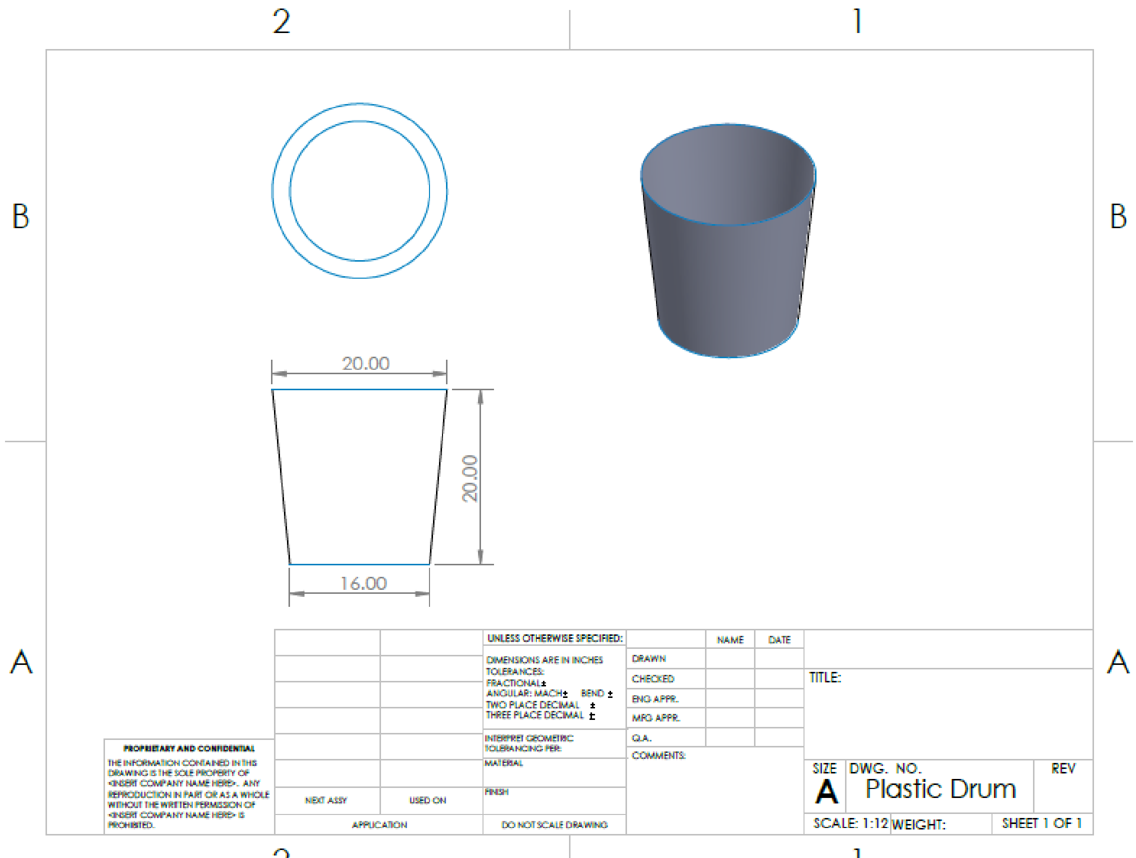
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COMMENTS:
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A
Plastic Drum
SCALE: 1:12
WEIGHT:
SHEET 1 OF 1
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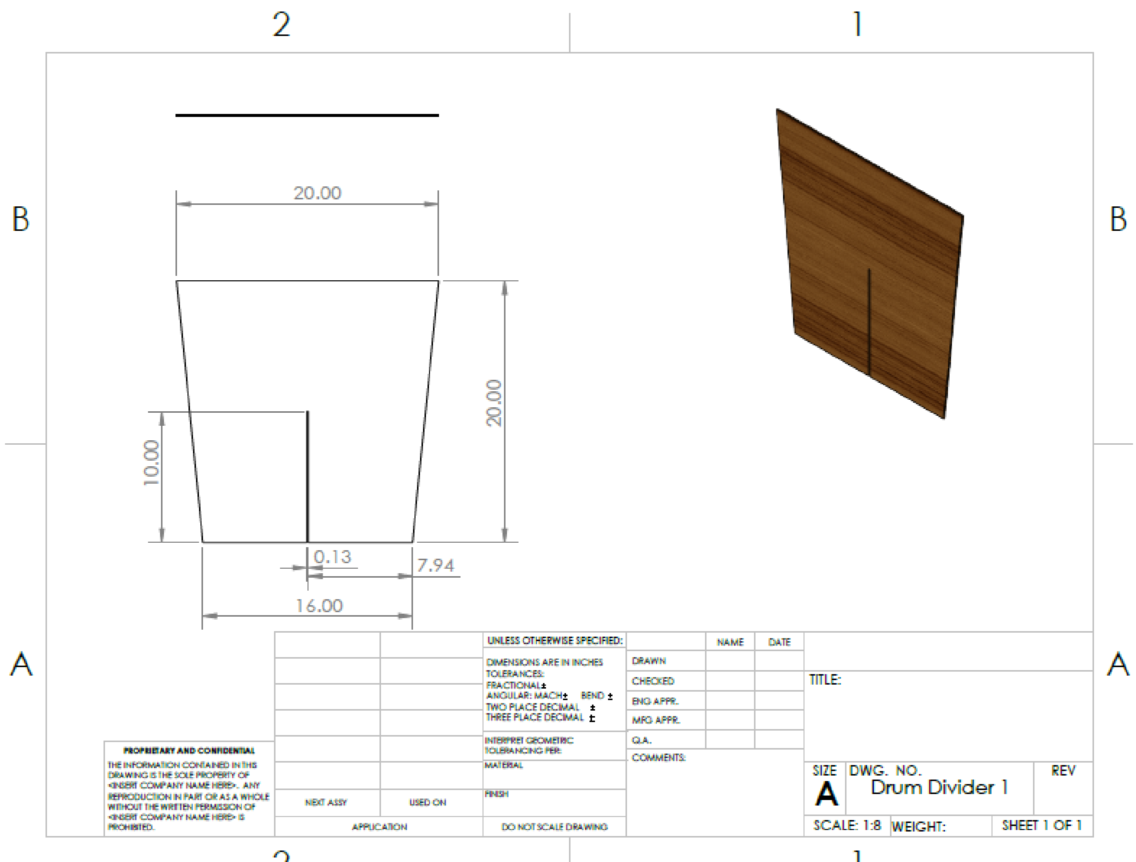
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SCALE: 1:8
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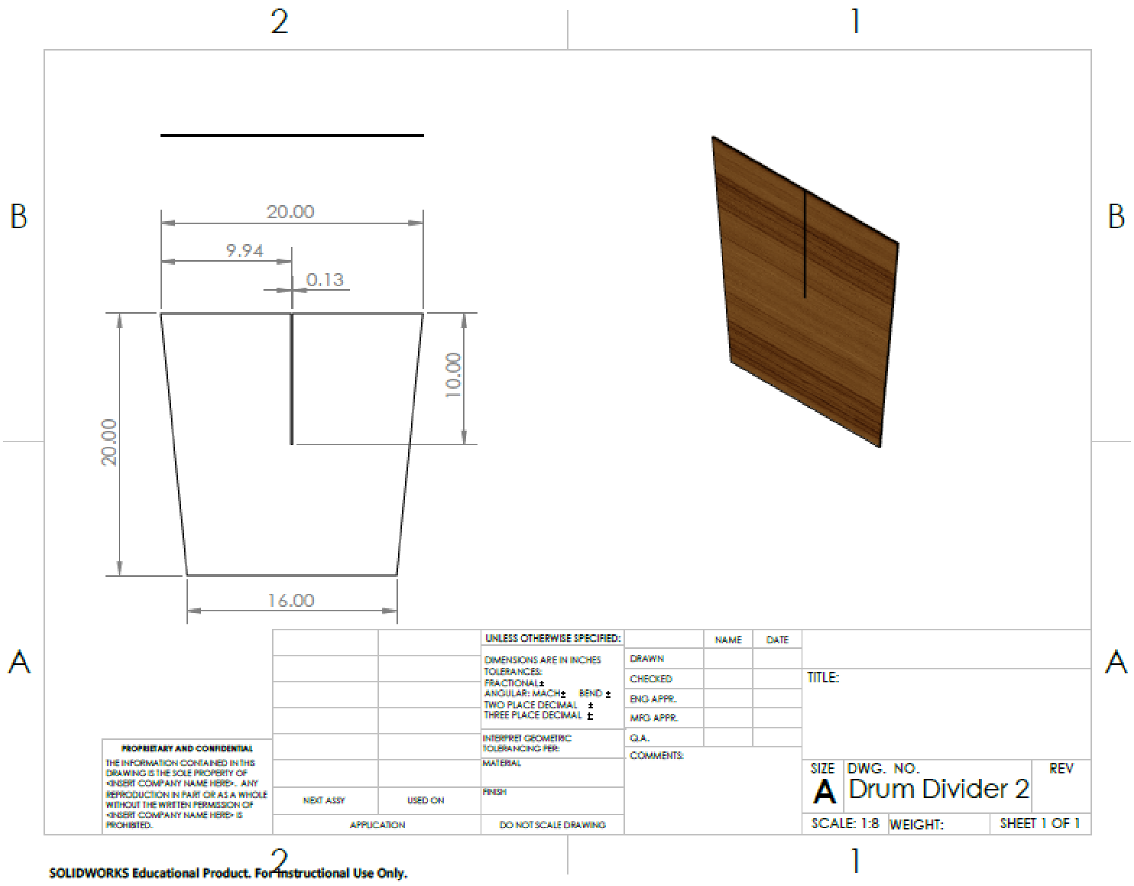
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Drum Divider 2
REV
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WEIGHT:
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PROPRIETARY AND CONFIDENTIAL
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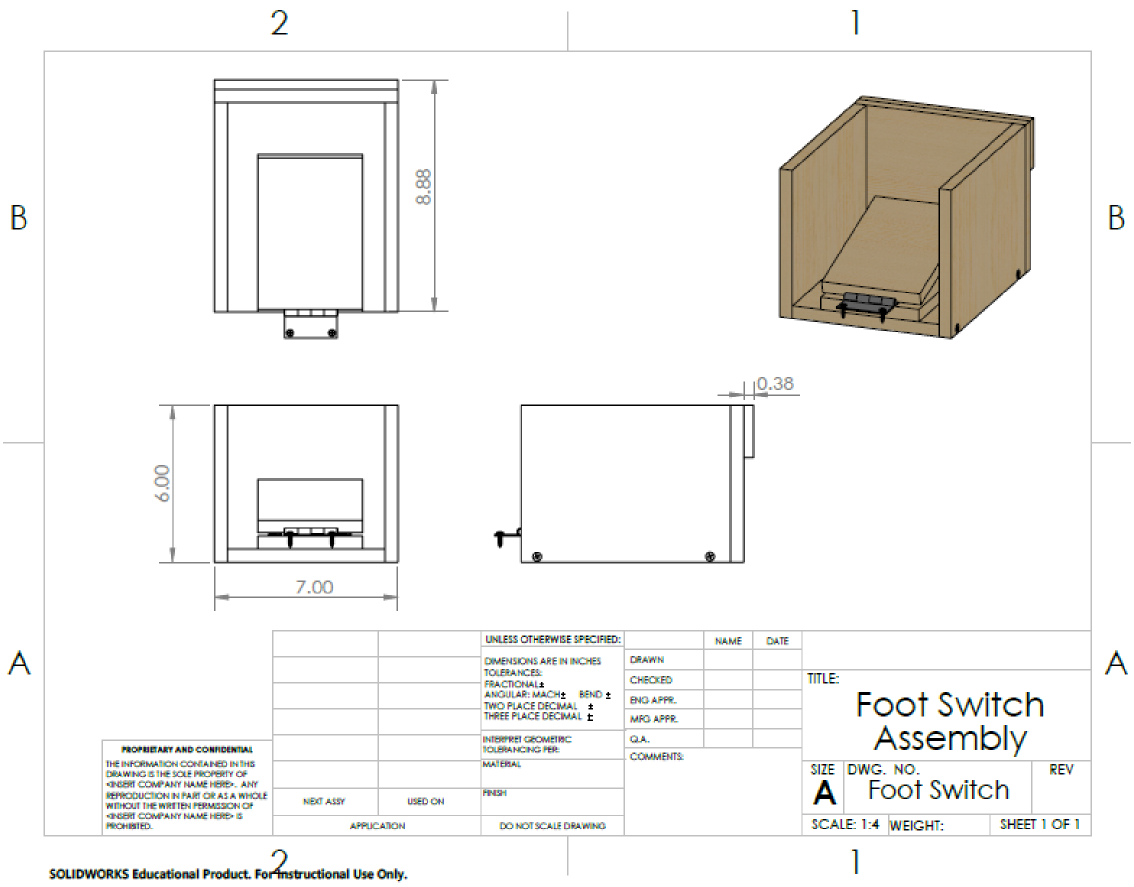
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COMMENTS:
TITLE:
Foot Switch Assembly
SIZE
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Foot Switch
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SCALE: 1:4
WEIGHT:
SHEET 1 OF 1
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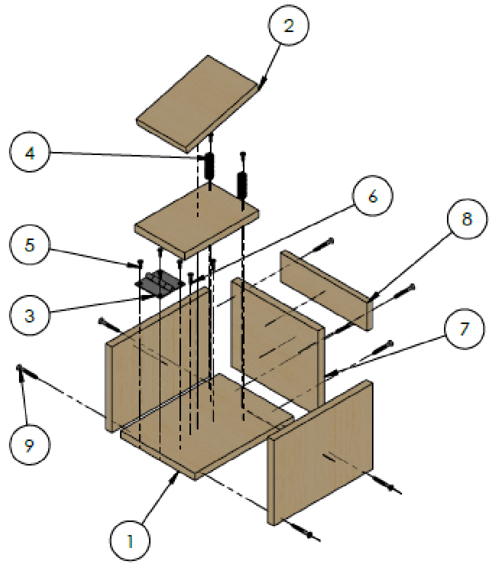


| ITEM NO. | PART NUMBER | DESCRIPTION | Exploded View/QTY. |
|---|---|---|---|
| 1 | Foot Switch Box Sides | | 3 |
| 2 | Foot Switch Pedal | | 2 |
| 3 | 1586A24 | Hinge | 1 |
| 4 | 9657K352 | Spring | 2 |
| 5 | 93360A220 | Wood Screw | 6 |
| 6 | 90031A151 | Wood Screw | 2 |
| 7 | Foot Switch Box Back | | 1 |
| 8 | Foot Switch Box Spacer | | 1 |
| 9 | 90031A203 | Wood Screw | 8 |

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NEXT ASSY | USED ON | APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±
ANGULAR: MACH± BEND ±
TWO PLACE DECIMAL ±
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INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

NAME | DATE
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CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:

TITLE: Foot Switch Assembly

SIZE A | DWG. NO. Foot Switch Exploded | REV
SCALE: 1:4 | WEIGHT: | SHEET 1 OF 1

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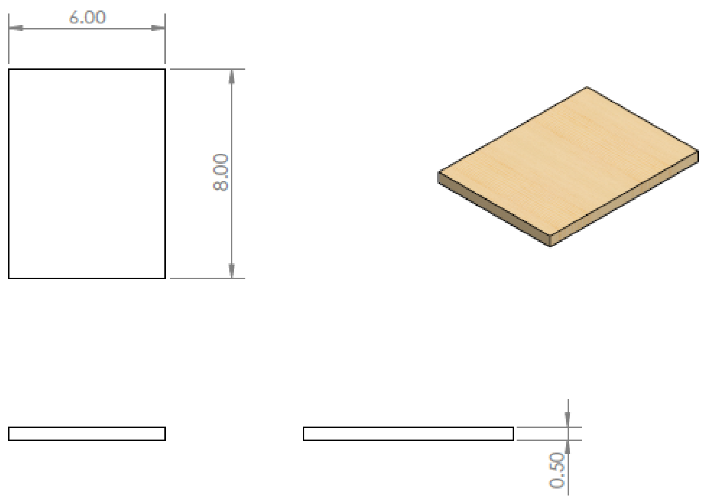


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CHECKED
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MFG APPR.
Q.A.
COMMENTS:

TITLE:

SIZE A | DWG. NO. Foot Switch Box-Sides, Bottom | REV
SCALE: 1:4 | WEIGHT: | SHEET 1 OF 1

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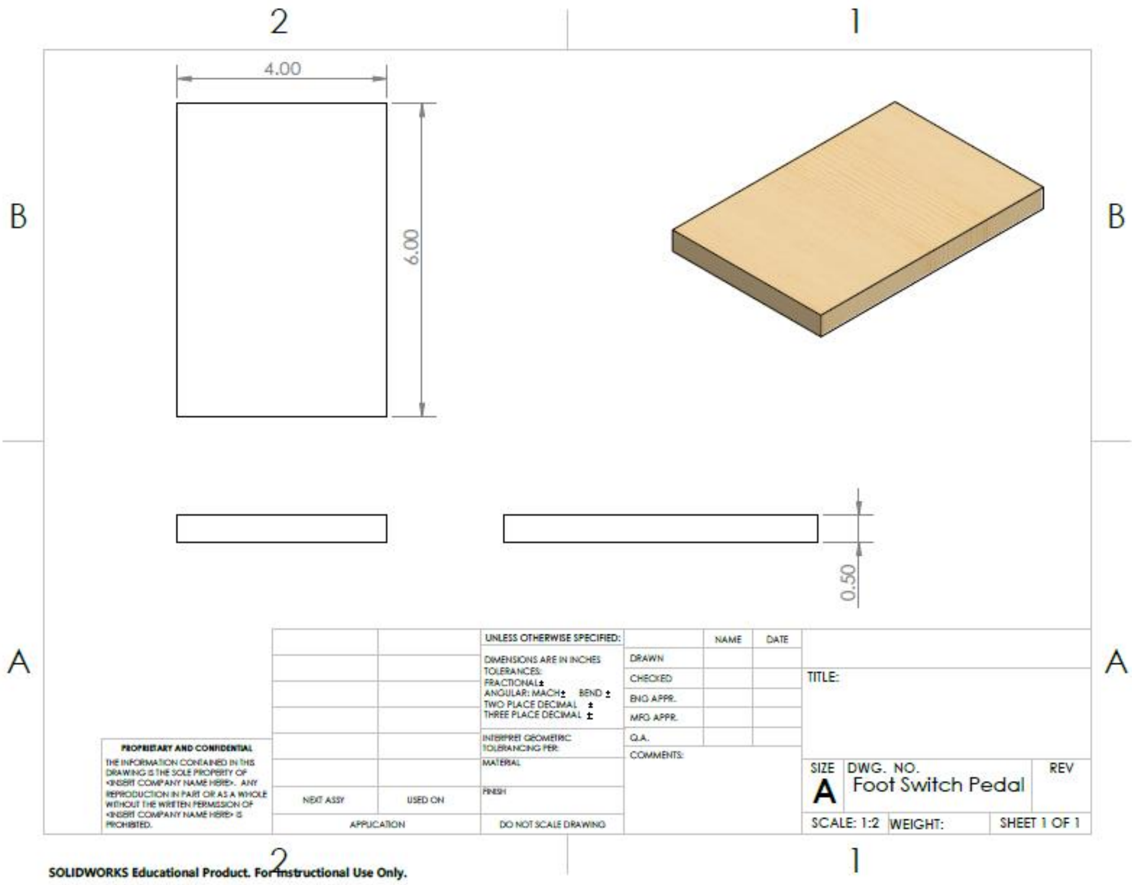
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DO NOT SCALE DRAWING
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COMMENTS:
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SIZE
A
DWG. NO.
Foot Switch Pedal
REV
SCALE: 1:2
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SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
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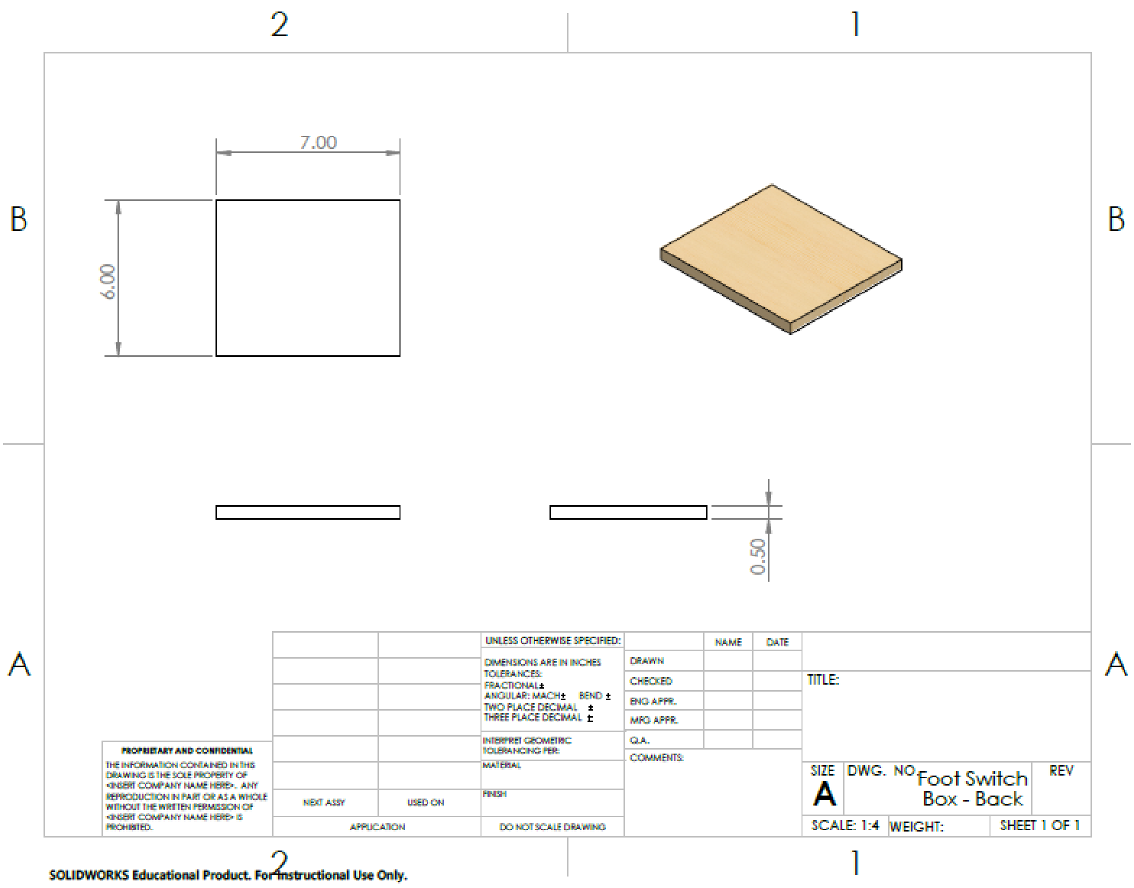
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USED ON
APPLICATION
NAME
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CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
SIZE
A
DWG. NO.
Foot Switch Box - Back
REV
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
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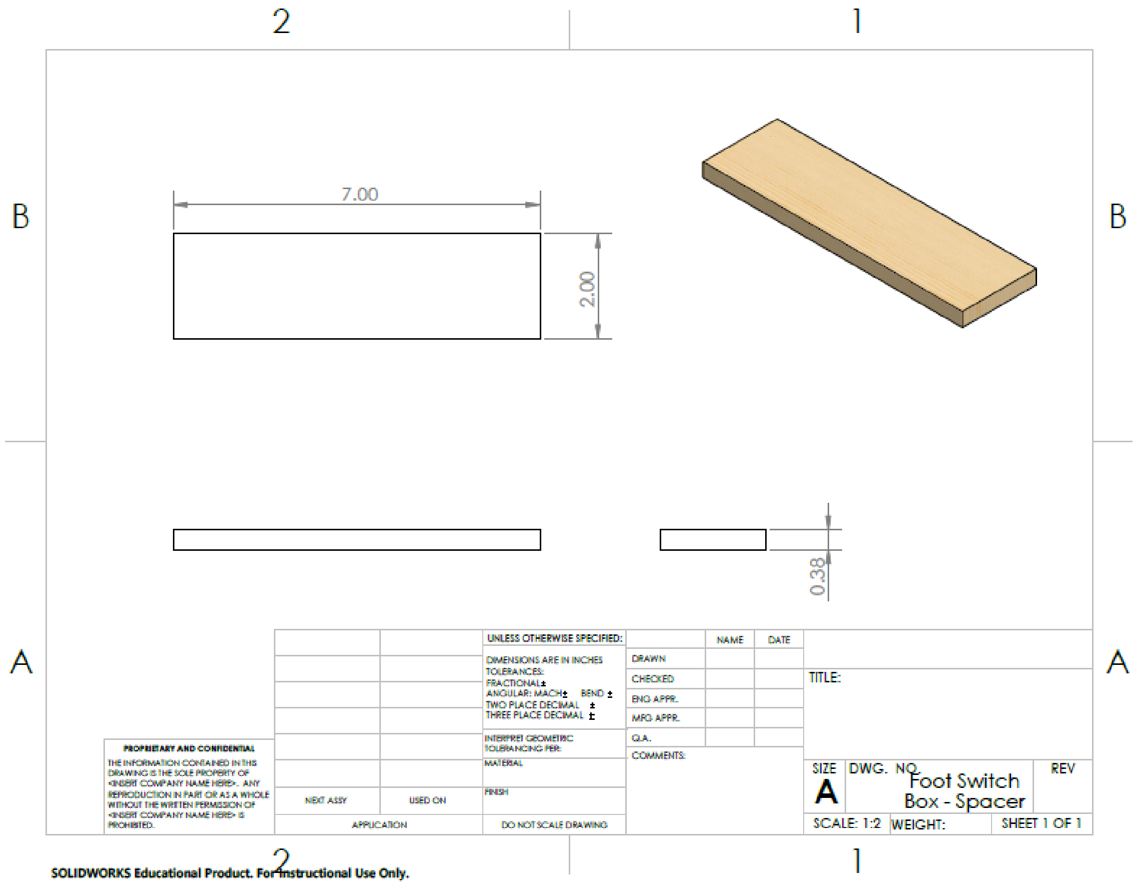
SOLIDWORKS Educational Product. For Instructional Use Only.




### 9.1.2 Sourcing instructions

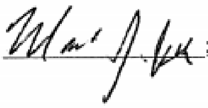
Refer to Appendix B under "Sourcing" for sourcing information for each part.

## 9.2 FINAL PRESENTATION

Link to the video presentation:

https://youtu.be/faoSsgyK280

# 10 TEARDOWN



**TEARDOWN TASKS AGREEMENT**

PROJECT: Recyclable Sorting NAMES: Javi Perez JP INSTRUCTOR: Professor Jakiela
Daniel Pogue DP
Robert O'Neill RCO

The following teardown/cleanup tasks will be performed:

**There is no necessary teardown/cleanup required.**

Instructor comments on completion of teardown/cleanup tasks:

CLEAN SOME FLOOR

Instructor signature: ______; Print instructor name: JAKIELA
Date: 8/12/19

(Group members should initial near their name above.)

# 11 APPENDIX A - PARTS LIST

**Table 9: Final Parts List**

| Item Number | Part Number | Description | Quantity |
|---|---|---|---|
| 1 | 9210011 | Metal Trash Barrel 55 Gallon (Steel) | 1 |
| 2 | N/A | Lid | 1 |
| 3 | N/A | Dolly | 1 |
| 3 | D437015 | Motor | 1 |
| 4 | N/A | Motor Bracket | 1 |
| 6 | 2176064 | Swivel Caster | 4 |
| 7 | 6483087 | Plastic Drum | 1 |
| 8 | 1291122 | Drum Dividers | 2 |
| 9 | 2737T261 | Sprocket | 1 |
| 10 | 93360A220 | Wood Screw | 13 |
| 11 | 92141A011 | Washer | 26 |
| 12 | 90272A198 | Machine Screw | 20 |
| 13 | 90480A009 | Hex Nut | 20 |
| 14 | 90272A836 | Machine Screw | 1 |
| 15 | 90480A195 | Hex Nut | 1 |
| 16 | N/A | Foot Switch - Box | 1 |
| 17 | 1586A24 | Hinge | 1 |
| 18 | 9657K352 | Spring | 2 |
| 19 | 90031A151 | Wood Screw | 2 |
| 20 | 90031A203 | Wood Screw | 9 |
| 21 | N/A | Scrap Metal | 2 |
| 22 | N/A | Timer Relay | 1 |

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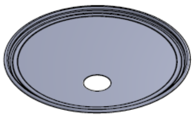
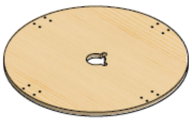
|---|---|---|---|
| 23 | N/A | AC Adapter | 1 |

## 12 APPENDIX B - BILL OF MATERIALS

**Table 10: Bill of Materials**

| Image | Nomenclature | Description | Part # | Price | Qty | Sourcing |
|---|---|---|---|---|---|---|
|  | Metal Trash Barrel 55 Gallon (Steel) | Used as the primary structure. All other components are housed inside and/or attached to the barrel. | 9210011 | $20 | 1 | https://www.ruralking.com/metal-trash-barrel-55-gallon<br><br>Will require pressure washing. |
|  | Lid | Hole cut into the top to allow recyclables to be placed inside. | N/A | N/A | 1 | Included with the barrel. |
|  | Dolly | ½" plywood. Casters and sprocket attached to the Dolly which connects to the motor. Supports the plastic drum and allows rotation. | N/A | Scrounged | 1 | Any scrap wood will work. Ensure wood is not warped. Easily found at local hardware stores. |
|  | Motor | Garage door geared motor with high torque output. Used to rotate the Dolly. | D437015 | $46.55 | 1 | https://www.northshorecommercialdoor.com/horman-d437015-motor.html?gclid=Cj0KCQjw9pDpBRCkARIsAOzRziu2Knk1h |

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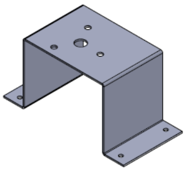
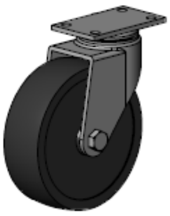
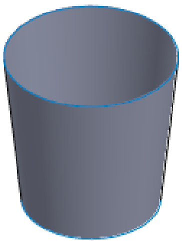
|---|---|---|---|---|---|---|
| | | | | | | yuPicE8LsDy0aSTsapnuj49LUaaAIGrdx2HDvddwHa_GSAaArK3EALw_wcB |
|  | Motor Bracket | 0.061” thick stainless steel bent. Used to hold motor to the bottom of the barrel. | N/A | Scrounged | 1 | Requires bending/forming. Any mild steel sheet at least 0.061” thick will be acceptable. Fou-nd at local hardware stores. |
|  | Swivel Caster | Swivel caster with 3” diameter wheels attached to the Dolly. | 2176064 | $5.79 | 4 | Menards |
|  | Plastic Drum | Menards trash can modified. Holds recyclables. | 6483087 | $9.97 | 1 | Menards |
|  | Drum Dividers | ⅛” thick 4’x4’ hardboard sheet. Used to separate the plastic drum into four compartments. | 1291122 | $6.19 | 2 | Menards |

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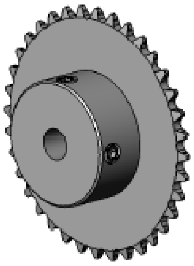
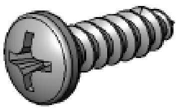
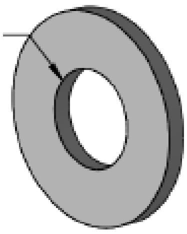
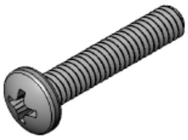
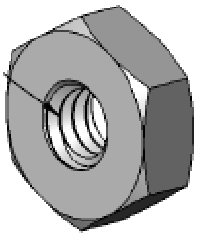
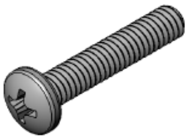
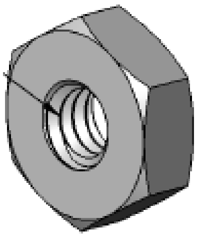
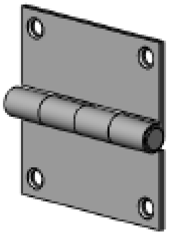
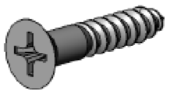
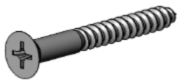
|  | Sprocket | Roller Chain Sprocket. Connects the motor shaft and the Dolly together. | 2737T261 | $22.71 | 1 | https://www.mcmaster.com/2737t261 |
|  | Wood Screw | ½" No. 6 wood screws used to fasten the Sprocket to the Dolly. Also used on the foot switch assembly. | 93360A220 | Scrounged | 13 | Menards or McMaster-Carr. Any similar hardware is acceptable. |
|  | Washer | 54 pack of ¼" washers. Used under heads and nuts of machine screws. | 92141A011 | 1.31 | 26 | Menards or McMaster-Carr. Any similar hardware is acceptable. |
|  | Machine Screw | Pack of 1" #10 screws with hex nuts included. Used to bold casters onto the Dolly and the motor bracket to the bottom of the primary structure. | 90272A198 | $3.59 | 20 | Menards or McMaster-Carr. Any similar hardware is acceptable. |
|  | Hex Nut | Included with the machine screw pack. | 90480A009 | N/A | 20 | Menards or McMaster-Carr. Any similar hardware is acceptable. |

| | | | | | | |
|---|---|---|---|---|---|---|
|  | Machine Screw | 1.5" long 1\4" screw holds the foot switch assembly to the drum. | 90272 A836 | Scrounged | 1 | Menards or McMaster-Carr. Any similar hardware is acceptable. |
|  | Hex Nut | Nut used for the ¼" machine screw. | 90480 A195 | Scrounged | 1 | Menards or McMaster-Carr. Any similar hardware is acceptable. |
|  | Foot Switch - Box | Made of ½" plywood. Used to make all sides, back bottom, pedals, and spacer of the foot switch. This is used by the operator to send a signal to the timer relay and motor for operation. | N/A | Scrounged | 1 | Easily found at local hardware stores. Any similar hardware is acceptable. |
|  | Hinge | Used to form a hinged point between two foot pedal parts. | 1586A 24 | Scrounged | 1 | Menards or McMaster-Carr. Any similar hardware is acceptable. Easily found at local hardware stores |
|  | Spring | Used between the foot pedals so the metal points do not make contact. | 9657K 352 | Scrounged | 2 | Menards or McMaster-Carr. Any similar hardware is acceptable. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | Easily found at local hardware stores |
|  | Wood Screw | ¾” long #6 screw. Used for construction of the foot switch assembly. | 90031 A151 | Scrounged | 2 | Menards or McMaster-Carr. Any similar hardware is acceptable. Easily found at local hardware stores |
|  | Wood Screw | 1.5” long #8 screw. Used for construction of the foot switch assembly. | 90031 A203 | Scrounged | 9 | Menards or McMaster-Carr. Any similar hardware is acceptable. Easily found at local hardware stores |
| N/A | Scrap Metal | Bent over piece of metal used to complete a circuit on the switch. | N/A | Scrounged | 2 | Easily found at local hardware stores |
|  | Timer Relay | Used to control the amount of time the motor is powered allowing for the bins to rotate properly. | N/A | $12.99 | 1 | https://www.amazon.com/gp/product/B07V24WJ4S/ref=ppx_od_dt_b_asin_title_s00?ie=UTF8&psc=1 |

| | | | | | | |
|---|---|---|---|---|---|---|
|  | AC Adapter | Input:<br><br>120V 60Hz<br><br>Output:<br><br>12VDC<br><br>700mA<br><br>Used to power the motor and timer relay. | N/A | Scrounged | 1 | Can be found on many electronics.  Go odwill or Savers is a good place to look. |
| | | | Total Cost: | $146.47 | | |

## 13 APPENDIX C - COMPLETE LIST OF ENGINEERING DRAWINGS

Below is a link to a finalized set of Solidworks drawings for individual parts and the assembly:

https://drive.google.com/drive/folders/11sCq3lP1nNz7achnuPzKPapth2Z-kG0q?usp=sharing

# 14 ANNOTATED BIBLIOGRAPHY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