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The Automatic Bartender

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Executive Summary

For our Senior Design project, we designed and built an Automatic Drink Mixer for at-home use. Our ideal customer is someone who enjoys cocktails, but dislikes the hassle of measuring out ingredients and pouring them for each drink. Instead, they can use our device to make multiple drinks at once, without needing to measure or pour individual ingredients.

We knew that the circuitry and programming would be the hardest part of this project, since we didn't have much experience in those areas. To accelerate the assembly of the machine and focus on the internal components, we bought ready-made parts to create the housing, instead of fabricating them ourselves. For the internal parts, we used a breadboard, jump wires, relays, valves, tubing, and an Arduino. We studied various open-source projects on the internet to learn how to correctly connect everything together.

This machine has four containers, which can be filled with any ingredients the user desires. Each container has its own tubing system with an electric solenoid valve that controls the flow. Through Arduino, the user can vary the amounts of each ingredient dispensed into the cup, making for an unlimited amount of mixed drink recipes.

MEMS 411: Senior Design Project

Automatic Bartender

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1 INTRODUCTION AND BACKGROUND INFORMATION

1.1 INITIAL PROJECT DESCRIPTION

The automatic bartender will hold 2 liquors and 2 mixers. When the user selects the option to make a drink, the device will pour out the required amounts of liquid into a container, via tubing that feeds into the container. The container has an internal stirrer to mix the components together, and then empties into a cup. The end result is a finished cocktail, and the machine is designed for residential use.

1.2 EXISTING PRODUCTS

“The Inebriator”

Figure 1 – Picture of “The Inebriator”

https://www.theinebriator.com/

This product is powered by an Arduino, and has a console for the user to select their drink. Once the cocktail is selected, the cup translates across the board, and the product dispenses the appropriate liquids. The cup slides to the left when the drink is complete.

“Somabar”

Figure 2 - Picture of "Somabar"

http://somabar.com/

This device has six replaceable containers, which it draws from and mixes internally before dispensing the cocktail into the glass. There is also a smaller container for bitters or syrup. It is controlled through Wifi with your smartphone.

“SmarTender”

Figure 3 – Picture of "SmarTender"

http://smartbarusa.com/

This device is for commercial use, and is a full bar sized machine that has wheels and makes 300 different drinks. The console and spout are on top of the bar, while the liquors and mixers are beneath. The console has a touch screen which allows you to choose your drink, and there is an insulated compartment for ice as well as garnishes.

1.3 RELEVANT PATENTS

Patent No.: US 6,945,157 B2

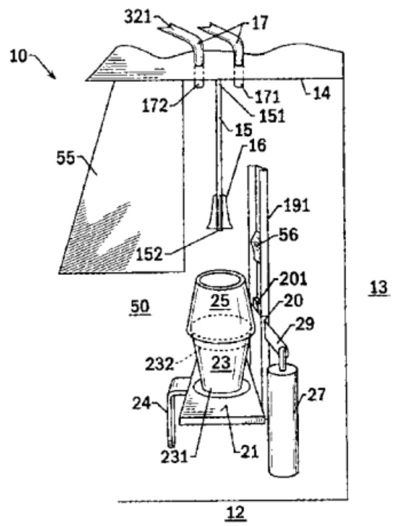


Figure 4 – Picture of Patent No.: US 6,945,157 B2

This is an automatic flavor-injected blending apparatus. There is software with the apparatus that receives the selected flavor, and then blends it with the existing liquid inside.

Patent No.: US 8,287,177 B2

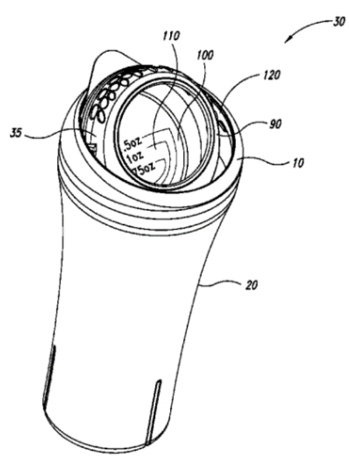


Figure 5 – Picture of Patent No.: US 8,287,177 B2

This is like a cocktail shaker, but with a rotatable top serving the functions of measuring, mixing, and dispensing. It does not come with any liquid, but rather serves as a do-it-all vessel for cocktail making.

1.4 CODES & STANDARDS

One standard we found is DS/IEC 60335-1, which deals with the safety of electrical applicances for household environment and commercial purposes, their rated voltage being not more than 250 V for single-phase and 480 V for others. This standard deals with the reasonably foreseeable hazards presented by appliances and machines that are encountered by all persons. However, in general, it does not take into account: - children playing with the appliance; - the use of the appliance by very young children; - the use of the appliance by young children without supervision.

Another standard is IEC 60730, which defines the test and diagnostic methods that ensure the safe operation of embedded control hardware and software for household appliances. The IEC 60730 standard classifies applicable equipment into three categories: Class A: not intended to be relied upon for the safety of the equipment, Class B: to prevent unsafe operation of the controlled equipment, or Class C: to prevent special hazards.

1.5 PROJECT SCOPE

The concept our group will be working on this semester is a drink mixer for alcoholic beverages. The exact physical design of the drink mixer is still being decided on – but there are a few critical functions that it will have to be able to perform. The drink mixer will be able to hold multiple different types/variations of alcohol and the bottles will be easily interchangeable so that the user can switch alcohols and drink options with ease. The drink mixer will also have a user friendly electronic interface that determines the available drink combinations corresponding to the liquor that has been loaded into the mixer. The interface will communicate with the drink mixer to provide the correct quantities of each alcohol based upon the drink. In addition to these functions, our drink mixer will be geared towards a household application and thus must be aesthetically pleasing to the eye. We may choose to accomplish this by utilizing LED lights, brushed metals, etc.

1.6 PROJECT PLANNING

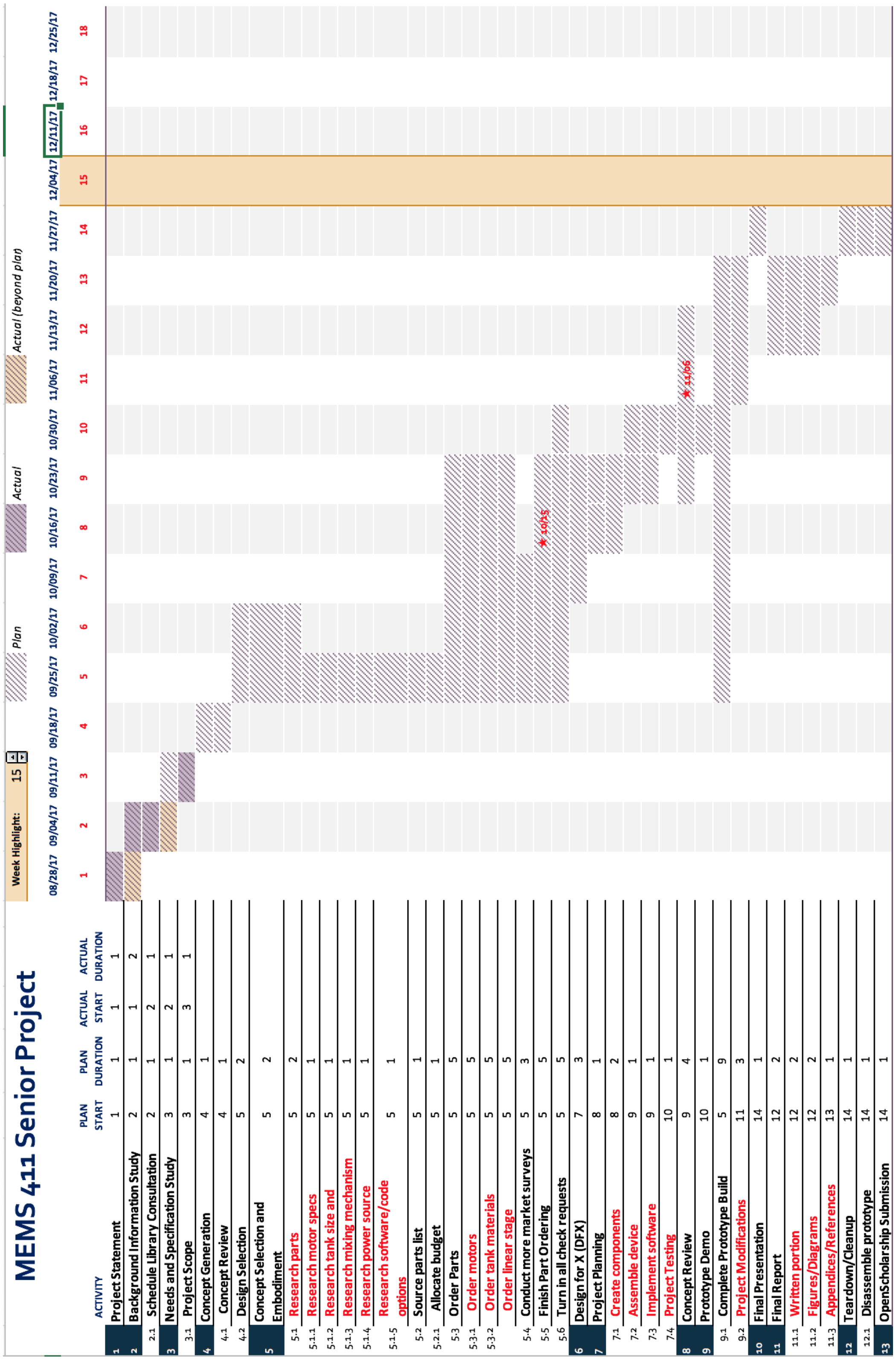


Figure 6 – Project Gantt Chart

1.7 REALISTIC CONSTRAINTS

Budget is the main constraining factor. If we use a motor, electronic interface, software, hardware, and other structural materials it is likely that this project will be pricey. We will need to simplify/cut out certain aspects so that we can fit the project in under budget. Additionally, the equipment we have available to design and build this prototype (along with the materials) may dictate the physical design.

1.7.1 Functional

Functionally, we are constrained by the components we can afford. The machine will only work as quickly as our components, for example the solenoid valves. Also, the function will be constrained by the size of our machine. Since we want to keep it relatively small, it won't be able to make one hundred drinks at a time.

1.7.2 Safety

With regard to safety, we are again constrained by the materials we can afford. For example, the wooden dowel rods may have splinters, but we could not afford aluminum rods. Additionally, we used a breadboard and jumper cables, which is not as safe as properly soldered connections.

1.7.3 Quality

The quality of our design is also constrained by our budget. Quality takes into account function, and the drinks we make are not the highest quality because of our functional limitations.

1.7.4 Manufacturing

We decided not to manufacture many parts, instead we saved time by buying already made buckets from Menard's for the housing. We cut wood for the base and the shelf, and bought wooden dowels for the rods.

1.7.5 Timing

Time was definitely a constraint. With more time, we could test our design further and make sure it works 100% of the time. Currently, we'll have to fix certain parts each time before getting it to work.

1.7.6 Economic

Economic constraints were the budget that we were given. We had to go over our budget in order to make everything work.

1.7.7 Ergonomic

Ergonomically, we are constrained by the size of the components we bought. We would've liked everything to be much smaller, which would make it more ergonomic for the user.

1.7.8 Ecological

Ecologically, we used plastic buckets, which are not the most environmentally friendly material. Initially, we wanted to make the whole design out of wood and metal. We would have used recycled material for both, making it more ecological.

1.7.9 Aesthetic

Aesthetically, we were constrained by the buckets we bought. They were already painted green and had large logos on them. Because of time constraints, we did not paint over or cover the logos.

1.7.10 Life Cycle
Our design is made from plastic and wood, which when subjected to cyclic loads and fatigue would not withstand stresses as well as if the components were made out of metal or stronger materials. So we would not expect this design to last for example 10 years, but rather would give it a life cycle of 2-3 years.

1.7.11 Legal
We did not take into account legal constraints, as our prototype will not be going into production. If we were taking our device to production and manufacturing, we would do more research to find the patents and intellectual property associated with building an automatic drink mixer such as ours.

1.8 REVISED PROJECT DESCRIPTION
The goal of the automatic bartender is to make mixing drinks fun, quick, and simple. Even the most inexperienced partygoer can use the automatic bartender's self-measuring ability and programmable drink options to make the perfect cocktail. The automatic bartender holds 1 liquor and 3 mixers in an upper storage compartment. When the user selects the option to make a specific drink, the automatic bartender will pour out the required amounts of liquid using a timing mechanism, using an Arduino controlled tubing system and solenoid valves. Our device is intended for household use.

2 CUSTOMER NEEDS & PRODUCT SPECIFICATIONS

2.1 CUSTOMER INTERVIEWS

Table 1 - Customer Interviews Table

Customer Data: Automatic Drink Mixer

Customer: Jimmy McMullen, Alex Johnson, Jackson Kelner (Senior WashU students)

Address: University Drive

Date: 8/17/2017

Question	Customer Statement	Interpreted Need	Importance
How quickly do you want your mixed drink to be dispensed?	Must be made in under a minute.	DM mixes drink in under 1 minute.	5
What size should the DM be?	Must fit on a kitchen counter.	DM is less than 2 cubic feet.	5
How many drink combinations should the DM offer?	Must offer at minimum 5 drinks options.	DM makes more than five drinks.	4
What noise level is tolerable?	Must be quieter than a microwave.	DM is quiet.	2

What size cups should the machine dispense into?	Red solo cup size.	DM works with red solo cups.	3
How often should it be cleaned?	Clean daily.	DM must be easily cleaned.	3
What other capabilities would you like?	Aesthetically pleasing Limits spillage Easy to move/transport	DM is visually attractive. DM is neat and precise. DM is light/portable.	4 3 4

2.2 INTERPRETED CUSTOMER NEEDS

Table 2 - Interpreted Customer Needs Table

Need Number	Need	Importance
1	DM mixes drink in under 1 minute.	5
2	DM is less than a cubic foot.	5
3	DM makes more than five drinks.	4
4	DM is quiet.	2
5	DM works with red solo cups.	3
6	DM must be easily cleaned.	3
7	DM is visually attractive.	4
8	DM is neat and precise.	3
9	DM is light/portable.	4

2.3 TARGET SPECIFICATIONS

Table 3 - Target product specifications for automatic drink mixer

Metric Number	Associated Needs	Metric	Units	Acceptable	Ideal
1	1	Time	seconds	<60	30
2	2, 5	Size	ft^3	2	1
3	3	# of drinks	integer	5	10

4	4	Sound	decibels	<58	30
5	9	Weight	lbs	<15	10
6	6	# of parts to clean	integer	2	1
7	7	# of compliments	integer	5	>100
8	8	Volume of spills	fl. oz	<4	0

3 CONCEPT GENERATION

3.1 FUNCTIONAL DECOMPOSITION

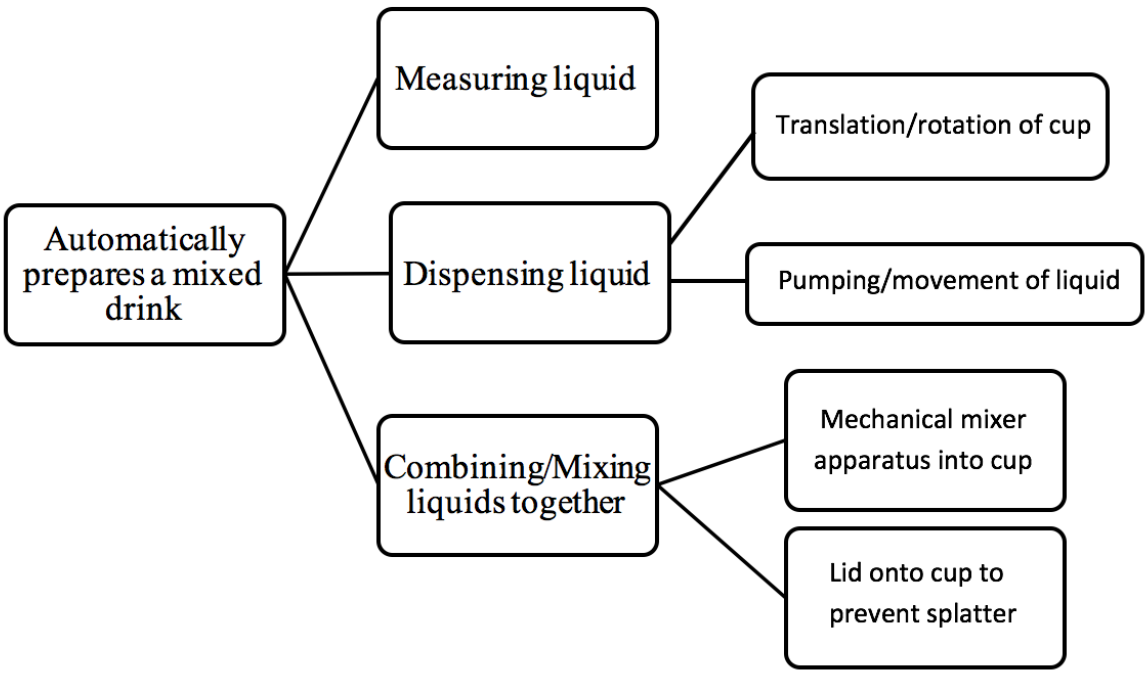
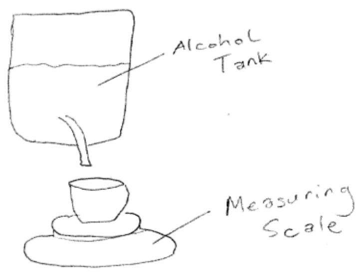
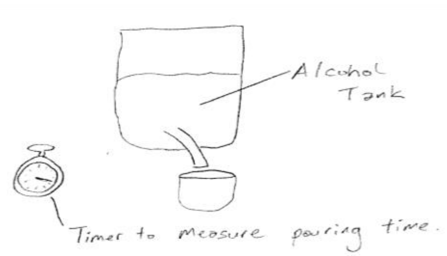


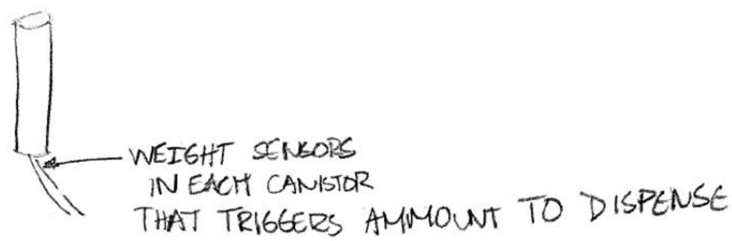
Figure 7 - Function tree for drink mixer

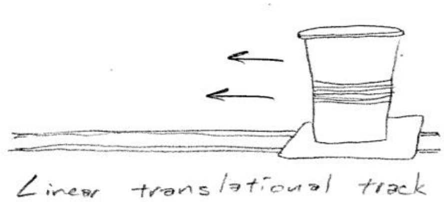
3.2 MORPHOLOGICAL CHART

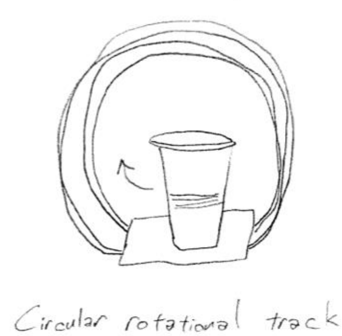
Table 4 - Morphological Chart

<table>
<tr><td>Measuring liquid</td><td>


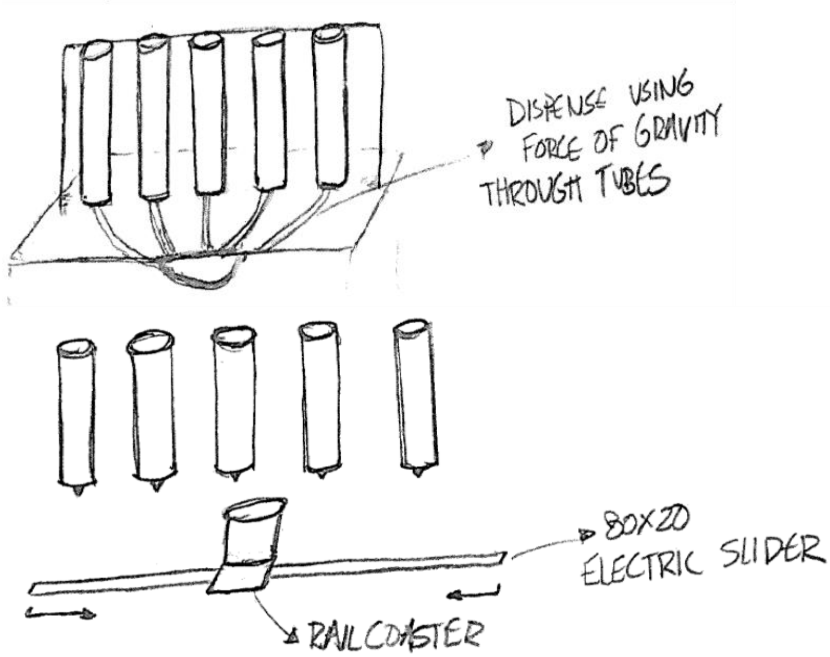


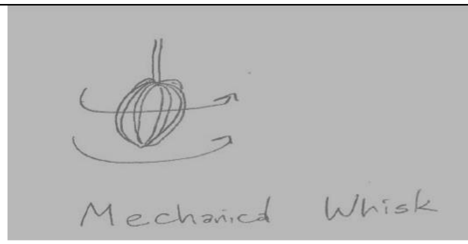
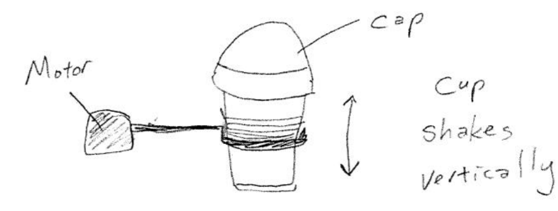
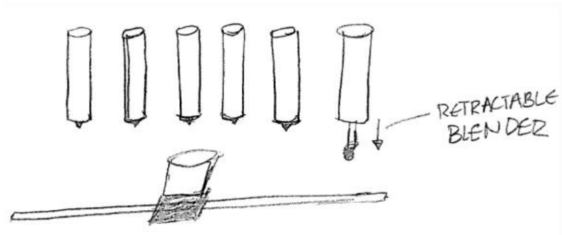
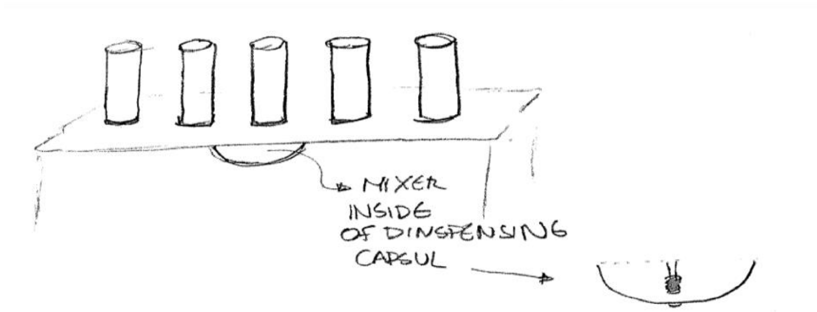


</td></tr>
<tr><td>Translation/rotation</td><td>




</td></tr>
</table>

Pumping/movement of liquid	

Mechanical mixer apparatus into cup	

3.3 CONCEPT #1 – "BOTTLE CANISTER"

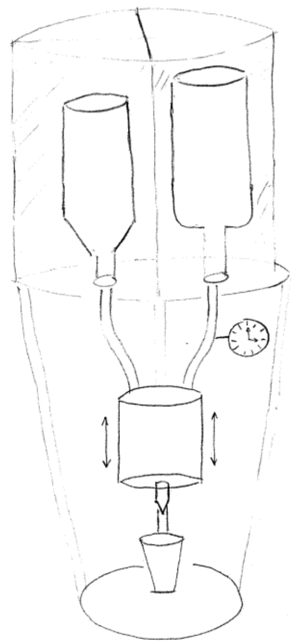


Figure 8 – "Bottle Canister" Design

Description: The bottles are housed inside of a cylindrical canister supported by rods attached to a base. A gate opens below the bottle caps and tubes with a timer sensor feature feed down from the top of the bottles to a center can which holds the combination of alcohols. This can is mounted to a motor which shakes the can up and down. Once done shaking, a valve is opened on the bottom of the can and the drink flows into a cup.

Solutions: Unit sits on floor/table

1. Measuring timer
2. No translation – cup stationary
3. Pumping via gravity
4. Motor shaker

3.4 CONCEPT #2 – "DRINK TABLE"

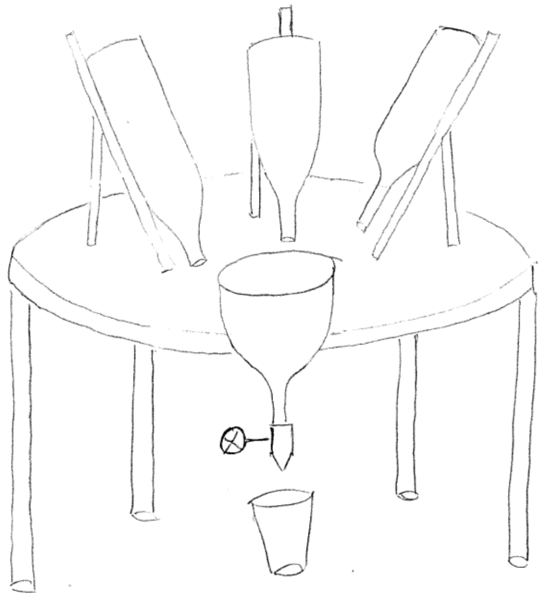


Figure 9 – "Drink Table" Design

Description: The bottles are held at a 45 degree angle supports and feed directly into a center console using gravity. A whisk is housed inside of the center console for mixing purposes. Once done mixing the valve on the bottom is opened and the drink is deposited below the table.

Solutions:

1. Measuring timer
2. No translation – cup stationary
3. Pumping via gravity
4. Whisk mixed

3.5 CONCEPT #3 – "DRINK CART"

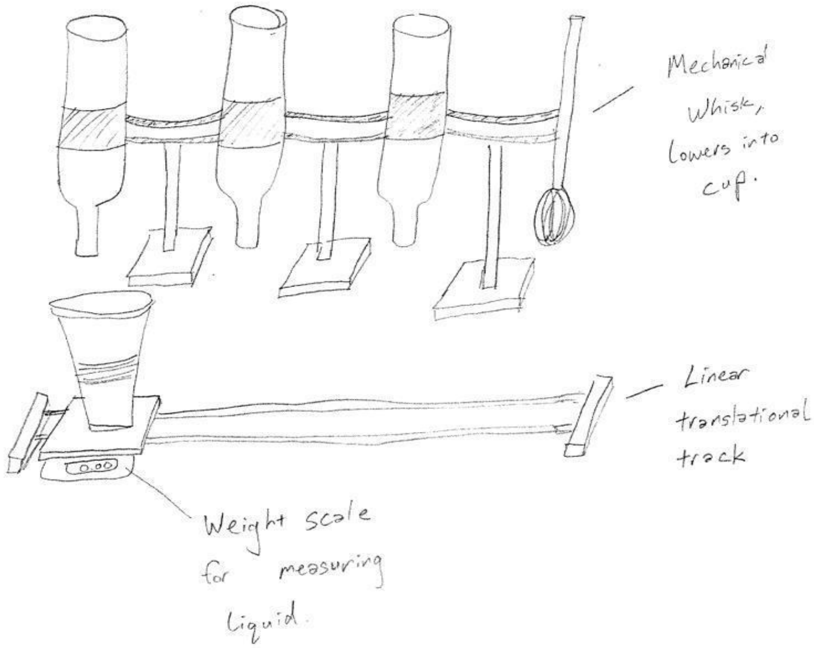


Figure 10 – "Drink Cart" Design

Description: The bottles are held by stands under which a cart translates along a linear motor driven rail. The cart is equipped with a scale through which the appropriate amount of alcohol for each drink is measured. After the cart finishes collecting liquid, it moves to the end of the track to be whisked before serving.

Solutions:

1. Weight scale
2. Linear track translation
3. Pumping via gravity
4. Whisk mixed

3.6 CONCEPT #4 – "DRINK WHEEL"

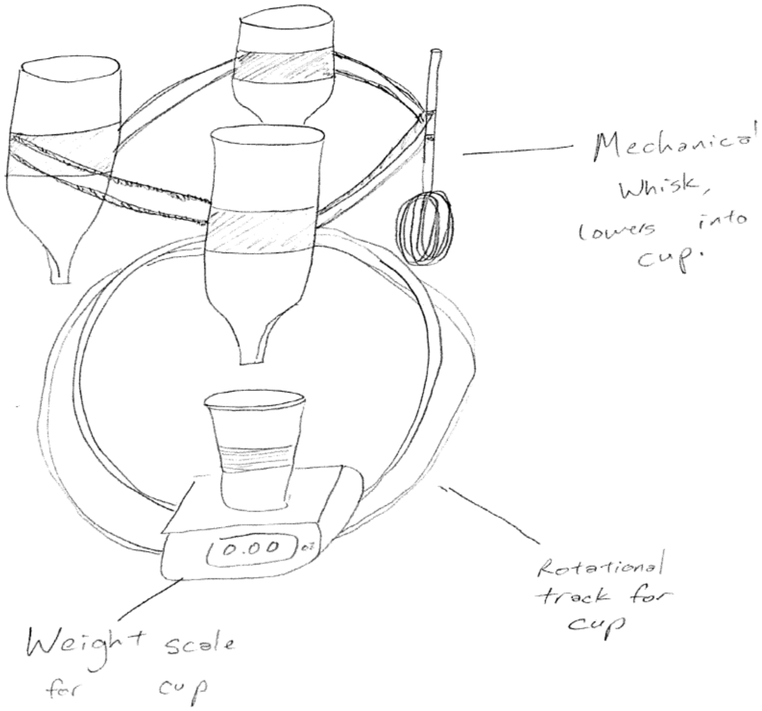


Figure 11 – "Drink Wheel" Design

Description: The bottles are held by stands under which a cart rotates along a circular motor driven rail. The cart is equipped with a scale through which the appropriate amount of alcohol for each drink is measured. After the cart finishes collecting liquid, it moves around the track to be whisked before serving.

Solutions:

1. Weight scale
2. Circular track rotation
3. Pumping via gravity
4. Whisk mixed

3.7 CONCEPT #5 – “ROTATING BOTTLE DEVICE”

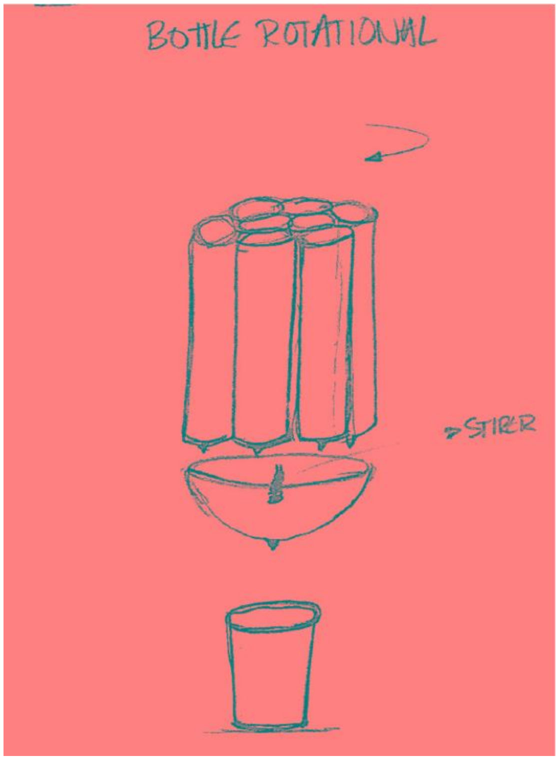


Figure 12 – "Rotating Bottle Device" Design

Description: The bottles are secured to a rotating center stand, which each pour desired amounts into a central vessel. In the vessel, there is a mechanical stirrer to mix the liquids together. The vessel then opens to release the mixed drink into a cup.

Solutions:

1. Rotating bottles
2. Central collection vessel
3. Pumping via gravity
4. Stirred to mix

3.8 CONCEPT #6 – "TRANSLATING VESSEL DEVICE"

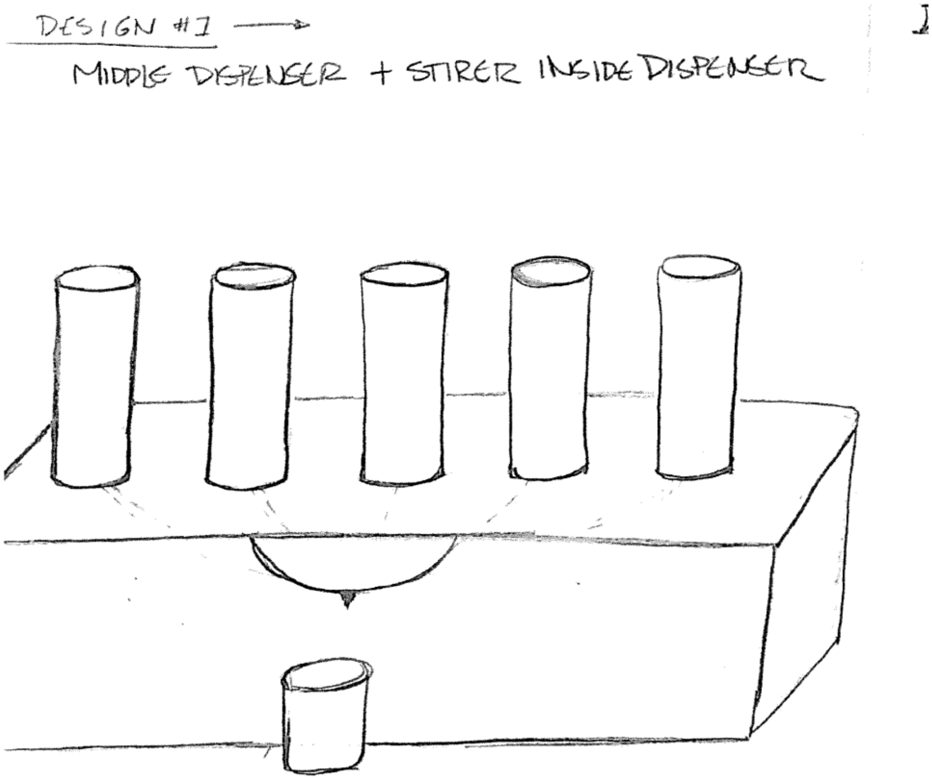


Figure 13 – "Translating Vessel Device" Design

Description: The bottles are secured to a rectangular stand, with a translating central vessel that collects fluid from each bottle. The vessel then has a stirrer which mixes the fluids, and then dispenses the final mixed drink into a fixed cup.

Solutions:

1. Central collection vessel
2. Linearly translating vessel
3. Pumping via gravity
4. Stirred to mix

4 CONCEPT SELECTION

4.1 CONCEPT SCORING MATRIX

Analytic Hierarchy Process

	Mechanical Safety	Cost of components	Time to completion	Physical size	# of drinks possible	Noise level	Weight	Maintenance	Aesthetic appeal	Volume of Spills	Row Total	Weight Value	Weight (%)
Mechanical safety	**1.00**	1.00	0.20	7.00	3.00	7.00	5.00	7.00	5.00	9.00	45.20	0.19	19.16%
Cost of components	1.00	**1.00**	0.20	5.00	1.00	5.00	7.00	7.00	5.00	7.00	39.20	0.17	16.62%
Time to completion	5.00	5.00	**1.00**	3.00	1.00	9.00	5.00	7.00	5.00	7.00	48.00	0.20	20.35%
Physical size	0.14	0.20	0.33	**1.00**	0.20	5.00	3.00	5.00	5.00	7.00	26.88	0.11	11.39%
# of drinks possible	0.33	1.00	1.00	5.00	**1.00**	7.00	3.00	5.00	5.00	7.00	35.33	0.15	14.98%
Noise level	0.14	0.20	0.11	0.20	0.14	**1.00**	0.33	1.00	0.33	1.00	4.46	0.02	1.89%
Weight	0.20	0.14	0.20	0.33	0.33	3.00	**1.00**	1.00	0.33	5.00	11.54	0.05	4.89%
Maintenance	0.14	0.14	0.14	0.20	0.20	1.00	1.00	**1.00**	1.00	3.00	7.83	0.03	3.32%
Aesthetic appeal	0.20	0.20	0.20	0.20	0.20	3.00	3.00	1.00	**1.00**	5.00	14.00	0.06	5.94%
Volume of spills	0.11	0.14	0.14	0.14	0.14	1.00	0.20	0.33	0.20	**1.00**	3.42	0.01	1.45%
										Column Total:	**235.86**	**1.00**	**100%**

Figure 14 – Analytic Hierarchy Process

Weighted Scoring Matrix (WSM)

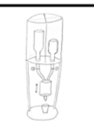
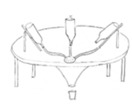
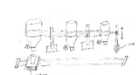
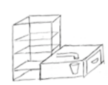
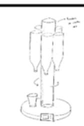
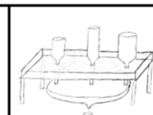
		Alternative Deisgn Concepts											
													
Selection Criterion	**Weight (%)**	**Rating**	**Weighted**	**Rating**	**Weighted**	**Rating**	**Weighted**	**Rating**	**Weighted**	**Rating**	**Weighted**	**Rating**	**Weighted**
Mechanical safety	19.16	4	0.77	5	0.96	1	0.19	4	0.77	2	0.38	5	0.96
Cost of components	16.62	4	0.66	4	0.66	2	0.33	2	0.33	3	0.50	3	0.50
Time to completion	20.35	3	0.61	2	0.41	2	0.41	2	0.41	3	0.61	2	0.41
Physical size	11.39	4	0.46	2	0.23	2	0.23	2	0.23	3	0.34	1	0.11
# of drinks possible	14.98	3	0.45	4	0.60	4	0.60	3	0.45	4	0.60	3	0.45
Noise level	1.89	2	0.04	4	0.08	3	0.06	4	0.08	2	0.04	4	0.08
Weight	4.89	4	0.20	2	0.10	2	0.10	2	0.10	3	0.15	2	0.10
Maintenance	3.32	2	0.07	3	0.10	1	0.03	3	0.10	4	0.13	4	0.13
Aesthetic appeal	5.94	5	0.30	2	0.12	4	0.24	4	0.24	3	0.18	2	0.12
Volume of spills	1.45	3	0.04	2	0.03	1	0.01	4	0.06	1	0.01	3	0.04
	Total score	3.587		3.278		2.198		2.752		2.943		2.895	
	Rank	**1**		**2**		**6**		**5**		**3**		**4**	

Figure 15 – Weighted Score Matrix

4.2 EXPLANATION OF WINNING CONCEPT SCORES

The first place concept scored above average in almost each selection criterion. In Mechanical safety, it received a rating of 4. We felt that since most of the mechanical components would be encased inside a housing, that the user would be harmed when using the device. Cost of components also received a rating of 4, since this design was not very complex. The mechanical components we envision it needing are sensors attached to canisters of liquid that would measure volume, and a motor to shake the mixing compartment. The device also scored highly (5) for aesthetic appeal, since we imagine it to look like a coffee maker. Areas in which it scored low are noise level and maintenance, since the shaker compartment moves, and because there are several different parts to clean.

4.3 EXPLANATION OF SECOND-PLACE CONCEPT SCORES

This design received a 5 rating for mechanical safety. The design had the least moving parts and for this reason was considered the safest. In addition, the design is a table design which reinforced the stability and safety of the design. This concept also scored high, for the cost of the components, number of drinks possible, and noise level. This was mainly because of the size of this design. The table design allowed for a low cost (simple parts), as well as a high number of drinks to be made. This concept scored low for time to completion, physical size, aesthetical peal, and volume of spills. This was due to the overall size of the design and its bulkiness.

4.4 EXPLANATION OF THIRD-PLACE CONCEPT SCORES

The third place concept incorporated a rotating bottle mechanism, and aesthetically resembled the first place concept. It received high ratings (4) for number of drinks possible and maintenance, since we imagined fitting bottles of alcohol or mixers to the stand. This would allow for a high number of drinks to be made. There is also no central mixing compartment, so not much cleaning or maintenance is required. The design scored a 1 for volume of spills, since there would be a lot of room for error if the bottles weren't correctly aligned with the cup. The design also scored quite low (2) for mechanical safety, since the bottles rotating are not covered, and injuries could occur.

4.5 SUMMARY OF EVALUATION RESULTS

Of the criteria listed in Figure 14, mechanical safety, cost of components, and time to completion scored the highest. The reason for this is because the safety of any household product is of high importance. In addition, the time to completion of making a drink was of great importance because if the machine cannot make a mixed drink faster than a human – there is no point to the machine. The cost of components was also weighted highly considering this project must be completed with a set budget that has been assigned to us. The cost of components for each design is an important constraint that we had to weigh heavily. The maintenance, volume of spills, and noise level of the machine was given the least weight in our matrix. These criterions were given low weight percentages because unless the maintenance frequency, volume of spills, and noise level are drastically intolerable, then these criterions cause little problem. For this reason, they were given the lowest weight percentages.

5 EMBODIMENT & FABRICATION PLAN

5.1 ISOMETRIC DRAWING WITH BILL OF MATERIALS

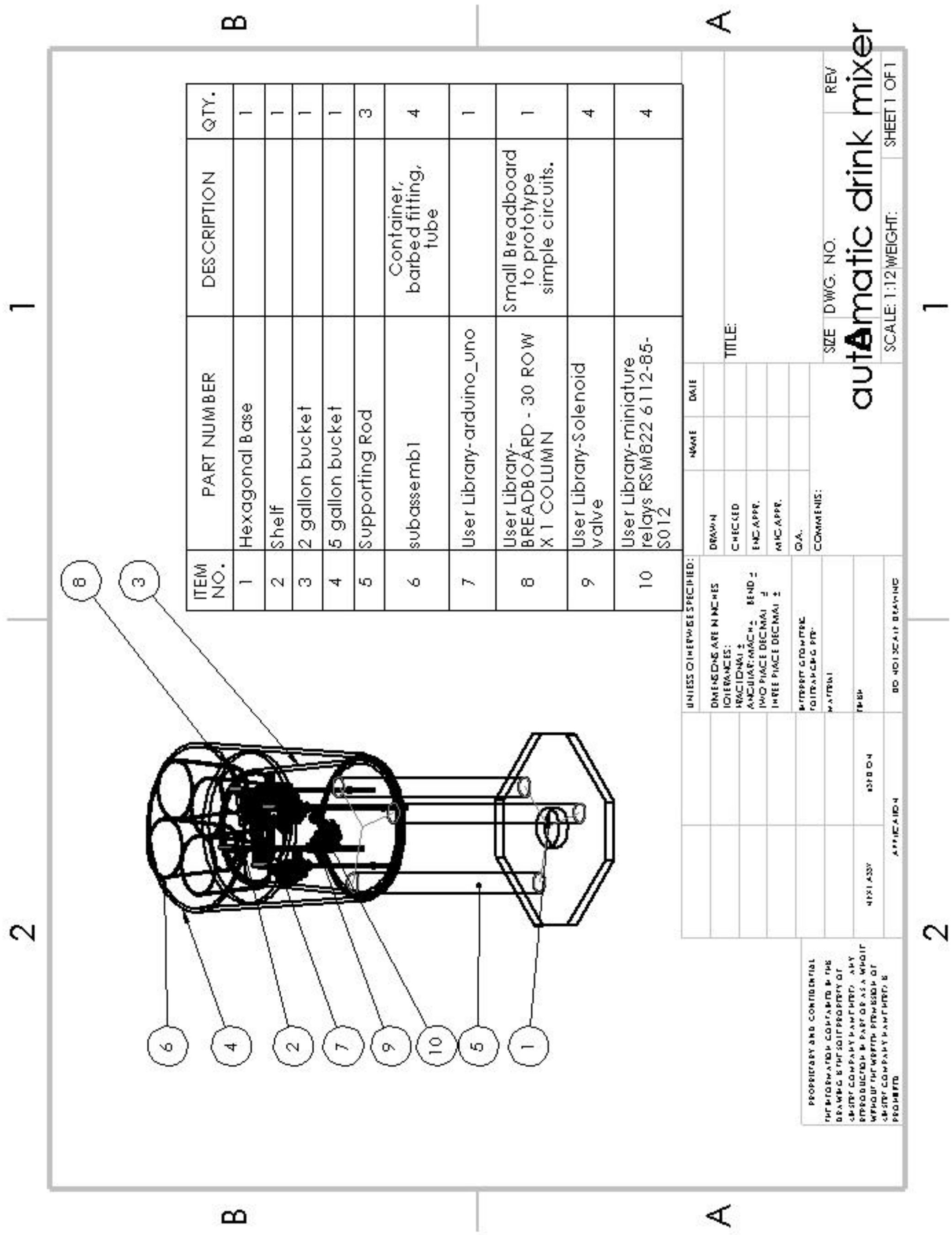


Figure 16 – Isometric Drawing with Bill of Materials

5.2 EXPLODED VIEW

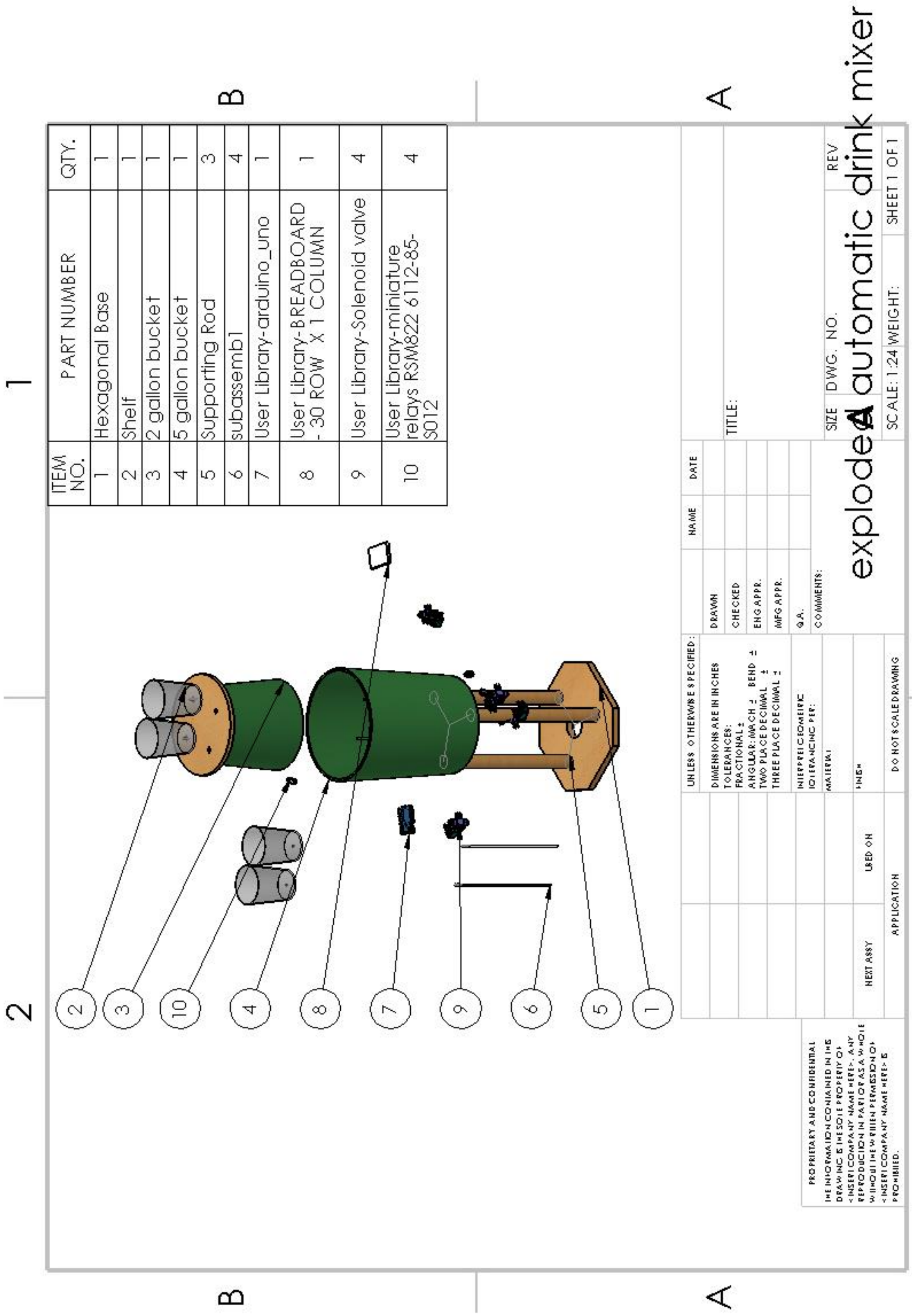


Figure 17 – Exploded view with Bill of Materials

5.3 ADDITIONAL VIEWS

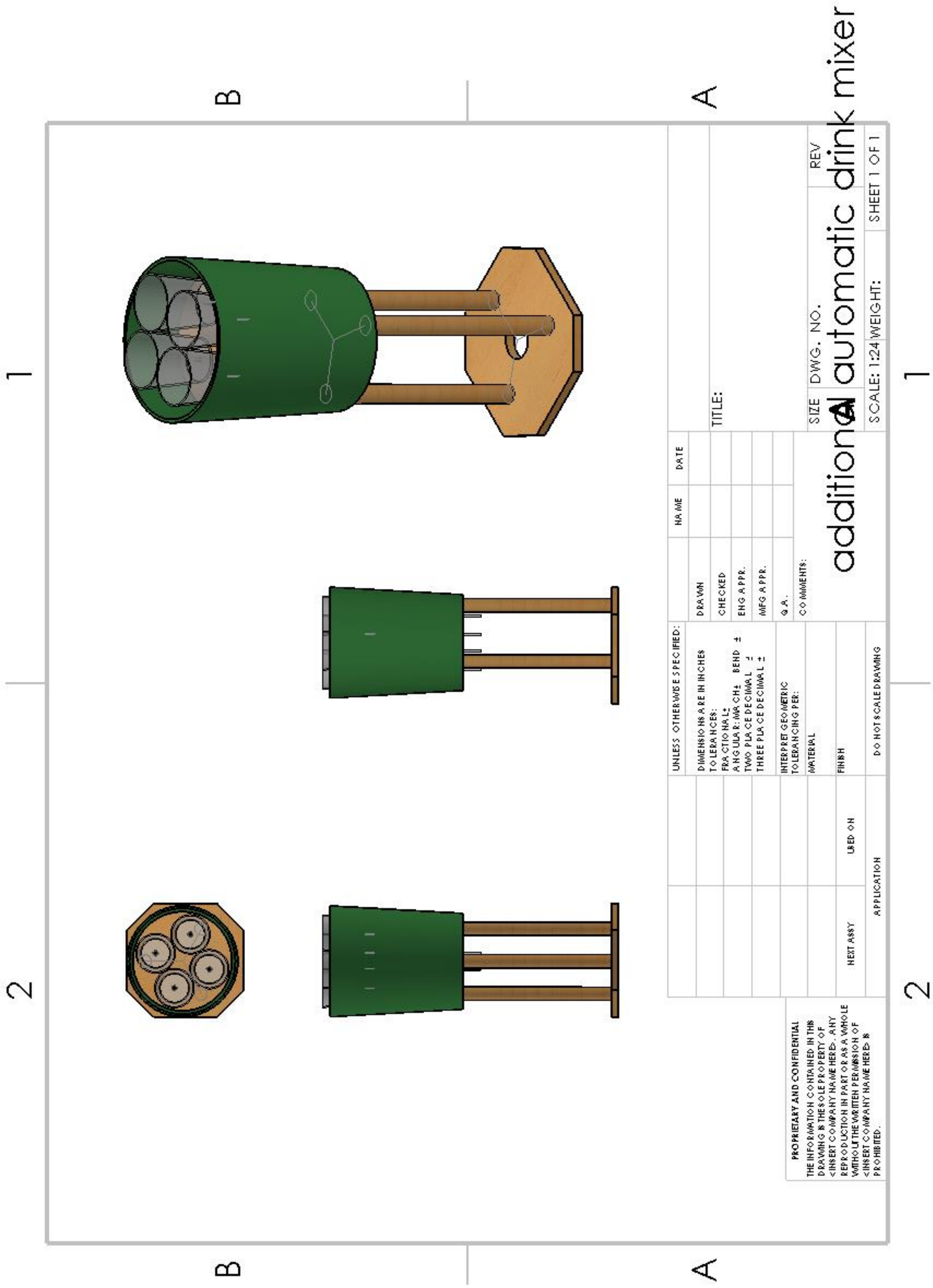


Figure 18 – Additional views (Top, front, right, isometric)

6 ENGINEERING ANALYSIS

6.1 ENGINEERING ANALYSIS RESULTS

6.1.1 Motivation

This analysis helps us determine the materials we should use in construction of our device and the risks associated with using the device. By doing the FEA analysis on the supporting rods, we can determine the stress concentrations in the rods based upon the mass and load applied on the structure. By doing this, we can determine what kind of elastic modulus, density, and other properties the rods must have in order to have a solid and strong structure. We expect to see that using wooden rods (poplar wood) will be sufficient for supporting the weight of the water and other components. The tipping test will include a moment analysis to estimate the amount of force required to tip the device over when a force is applied horizontally (as if being pushed) to the top of the device. We expect to see that our moment analysis will be yield a force that is very low, because it is simplified to just a rod with a point mass on the end. It is hard to approximate the stability provided by the base, which would increase the amount of force required to tip the device over.

6.1.2 Summary Statement of the Analysis

For the hand calculations, basic mechanical theory was applied. A free body diagram was drawn by hand, reducing the entire model to a rod and point mass structure, with a flat base secured by two points. A moment and force summation was used to solve for the minimum tipping force. In addition, the two reaction forces on the base plate were calculated by force summation. The tipping force was calculated by setting one of the reaction forces to zero, since when the device tips one of the reaction forces reduces to zero. This can be seen in Section 7.1.4. For the solidworks finite element analysis, a static test with a distributed load was performed. A distributed load, mimicking the load of the liquid drinks applied to the device, was used as the basis for this calculation. The results of this test are seen in section 7.1.4.

6.1.3 Methodology

The finite element analysis (static test with distributed load) was performed using Solidworks and is seen in section 7.1.4. In addition, the tipping test was conducted by hand as seen in section 7.1.4. A simplified model (rod with a point mass) was assumed for the purpose of these calculations. All of the experimental values used for the analysis was found from current device dimensions as well as hypothetical values of our liquids. Since no more than 100ml of liquid will be in each liquid container, and the device carries 4 liquid containers, a distributed mass of 400ml (or 4kg) was assumed for the purpose of our analysis.

6.1.4 Results

Shown below is a screen capture from the finite element analysis ran using SolidWorks. The red arrow shown is the direction of gravity, and an unseen distributed mass is applied to the wooden shelf in the large 5-gallon bucket. The distributed mass applied is 4 kg.

The analysis shows that stress is concentrated mainly in the wooden rods, as we expected. However, there is not a significant amount of stress, as shown by the legend.

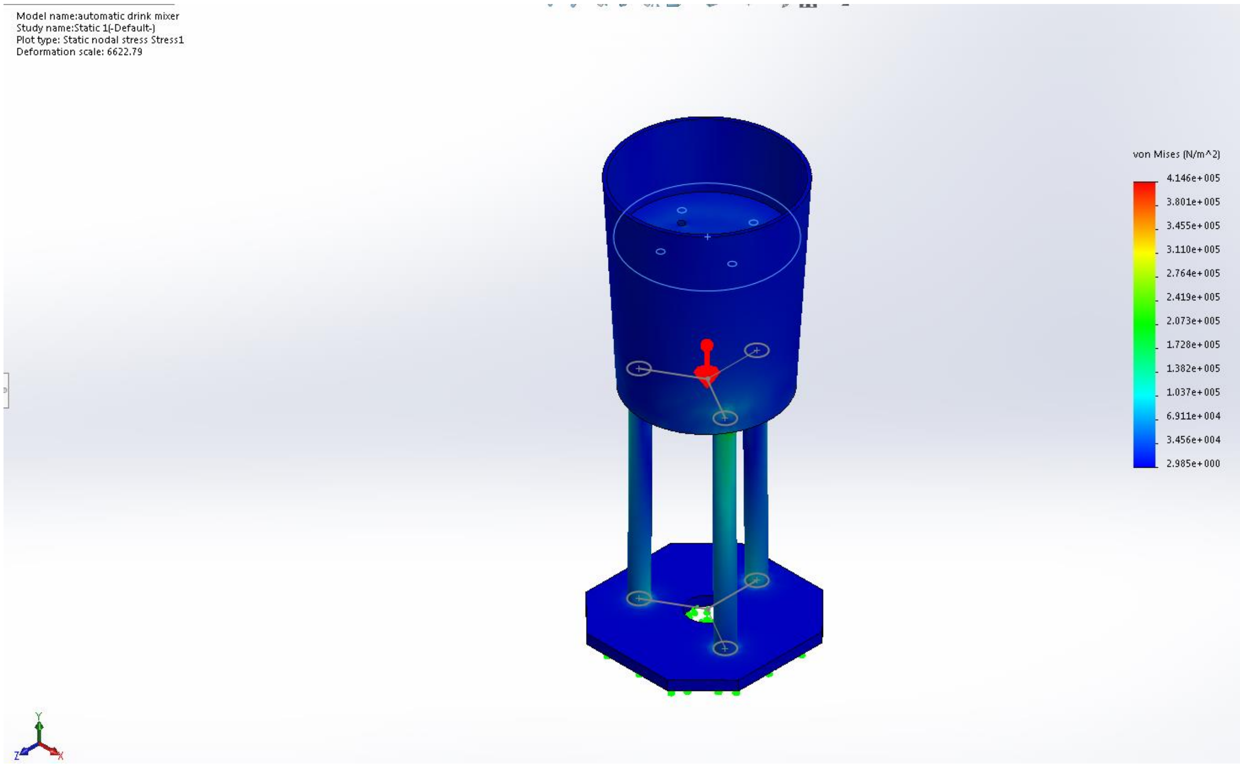


Figure 19 – Von Mises stress analysis

Shown below are the tipping test calculations. A rod with a point mass was assumed for simplicity and a force of 4.5N was found as the tipping force – when applied to the top of the device. This number is lower than expected because of the assumptions that we made simplicity.

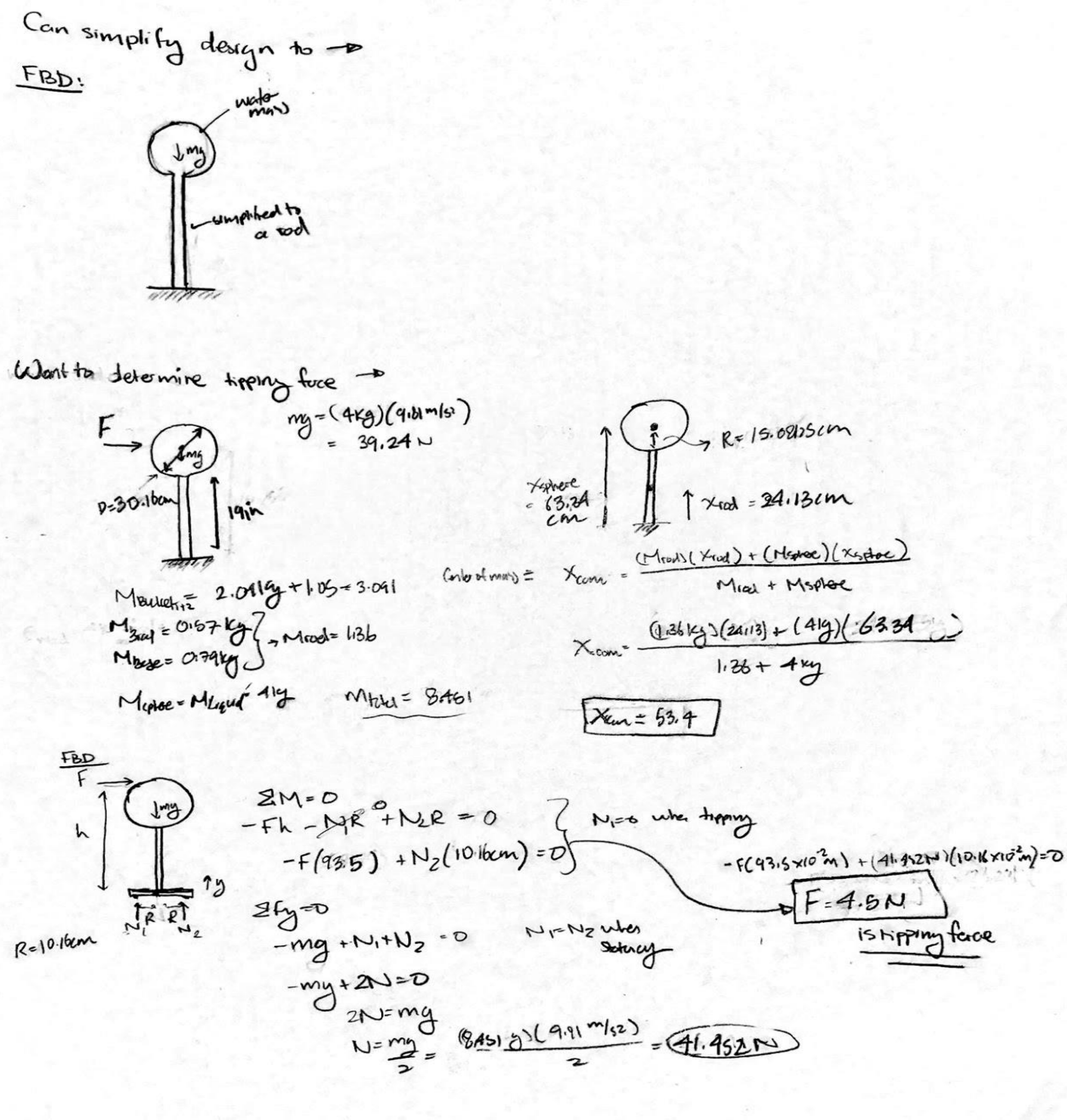


Figure 20 – Tipping test analysis

6.1.5 Significance

Two changes were made to the prototype design as a result of the FEA and tipping test. The plastic casing – housing the 4 different liquids – was changed to aluminum, from high density PE to prevent deformation of the casing and for aesthetic purposes. In addition, the 3 wooden supporting rods were shortened in length to raise the tipping force, and decrease the overall size and height of the device. Since this device is a household product, decreasing the overall height of the device was not only beneficial in increasing the tipping force, but also beneficial aesthetically. A more compact device is more aesthetically pleasing, and takes up less space in the kitchen of a person's home. Whereas the length of the rods was 16 inches before, we shortened them to 10 inches.

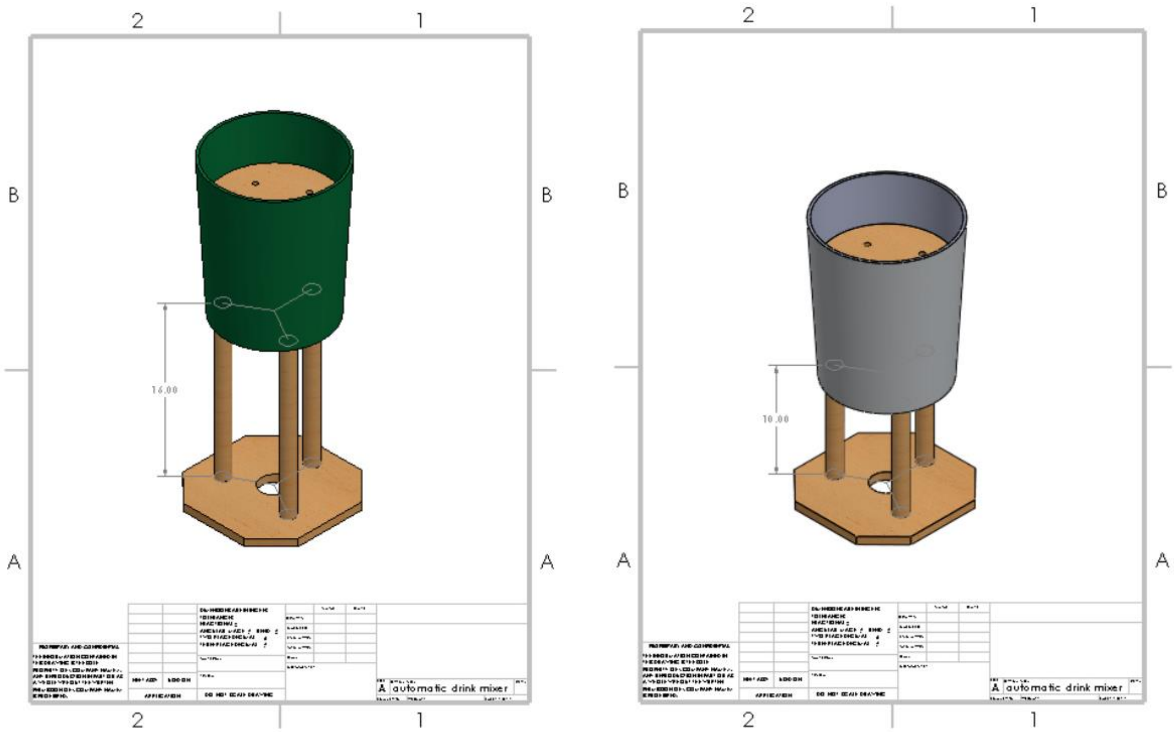


Figure 21 – Changes made after FEA Analysis

6.2 PRODUCT RISK ASSESSMENT

6.2.1 Risk Identification

Risk Name: Liquid Contamination

Description: This risk is associated with the liquids flowing through our tubing in our device. Poor cleaning and lack of maintenance could cause the tubing to become tainted with bacteria or mold. If the tubes and solenoid valves are not cleaned properly periodically there is a health risk.

Impact: 3

This risk would not cause the device to fail in any way mechanically or electrically, but would put the well being of the user at risk.

Likelihood: 2

With proper maintenance and cleaning of the tubing and solenoids the likelihood of this occurring is fairly low.

Risk Name: Shock Hazard

Description: This risk is associated with water possibly leaking from the tubes and solenoid fittings and coming into contact with the electrical components within the inner casing. If the electrical components came into contact with the water there could be short circuiting/sparking that could cause an electrical shock if the user came into contact with these components.

Impact: 4

This is a serious risk as it could pose a significant health risk to the user. Shocks could cause burns or other injuries.

Likelihood: 1

Since all electrical components are contained within an inner casing which seals the Arduino, breadboard, circuitry, and solenoid valves off from user/water contact, the likelihood of this shock hazard occurring is very low.

Risk Name: Fire Hazard/Melting

Description: One of the issues with our design was because of the wiring and circuitry layout it wasn't possible to shrink wrap all our connections. Instead tape had to be used to secure some of the connections. Additionally, some of the tape was not electrical tape – meaning that it has the possibility of melting and causing a fire.

Impact: 5

This would obviously be catastrophic if it was to occur. A fire would not only destroy the device, but also put the user and others in danger.

Likelihood: 3

If the device was operated for an extended period of time this would increase the likelihood of a fire occurring. If the device is not left on or powered for an excessive amount of time it most likely will not be an issue that has to be dealt with.

Risk Name: Tipping

Description: If enough force was applied on the device, the device has the possibility to tip over. The device is not extremely heavy, but it would still cause a mess and could cause minor injury if it did tip over.

Impact: 2

The event of tipping would likely not be catastrophic and would probably not significantly damage the device. It could cause minor injuries, especially to children, and would cause a mess as the drinks containers would likely spill.

Likelihood: 3

The device would tip over if enough force was applied, but because of the wide base it would difficult to tip over and would require quite a bit of force.

Risk Name: Spillage/Dripping

Description: This device uses buckets/containers of liquid and tubing/fittings. It is nearly impossible to make sure all connections and fittings are drip/leak free. There is also the possibility of liquid dripping out of the end of the tubes at the cup end.

Impact: 1

This risk would not affect the device or the users significantly, besides being a minor inconvenience.

Likelihood:

The event of spillage/drippage is very likely because of all the various connections that have to be accounted for.

Risk Name: Excessive Intoxication

Description: Since our device does involve alcohol and alcoholic beverages there is always the risk that those operating the device may be irresponsible and make decisions that endanger themselves or others while intoxicated.

Impact: 2

The impact would most likely be minimal.

Likelihood:

There are different degrees of intoxication naturally, so the likelihood of this occurring would vary.

6.2.2 Risk Heat Map

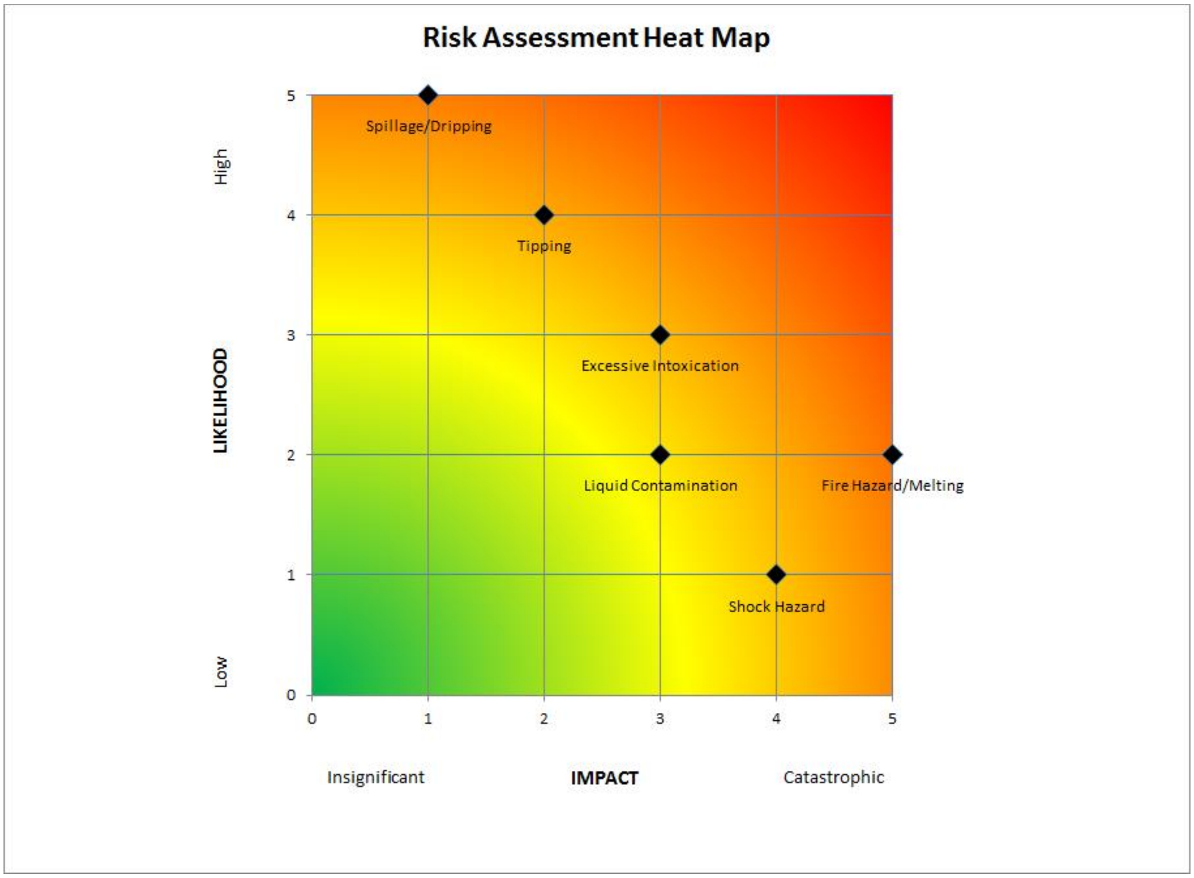


Figure 22 – Risk assessment heat map

6.2.3 Risk Prioritization

Based on the heat map and the impact and likelihood of each risk, it is clear that Fire Hazard/Melting and Shock Hazard should be prioritized above the rest of the risks. In a redesign/production we would make sure to shrink wrap all connections in the wiring so that we did have an issue with tape melting and becoming a fire hazard. The inner casing would also need to be waterproofed and sealed in a production model in order to ensure that no one could access wet electrical components and potentially shock themselves. We would also make it a priority to place a warning label about the potential hazards of alcohol on our device to minimize the risk of excessive intoxication.

7 DESIGN DOCUMENTATION

7.1 PERFORMANCE GOALS

1. Combine and mix one drink in under 30 seconds, from cup placement to retrieval.
2. Five different drink options with a set selection of liquors/mixers.
3. The total dispensed liquid volume per 10 drinks is +/- 40ml from the correct amount, as measured by the remaining canister liquid volume.
4. Volume of spills per cycle (one drink) is less than 10ml when 10 drinks are dispensed.
5. Capacity of drink mixer is sufficient for a minimum of 10 mixed drinks without refilling when any one drink is selected 10 times.

7.2 WORKING PROTOTYPE DEMONSTRATION

7.2.1 Performance Evaluation

During our prototype demonstration, we reached each of our five performance goals. This can be shown through the video the instructors have, as well as the video shown below. The only performance goal that was difficult to achieve was Goal #3, the goal associated with the error per 10 drinks. This goal was the most difficult because the flow rate of our valves and the kinks in the tubing varied from day to day making it hard to have a consistent code that gave us the same volume per drink every time.

7.2.2 Working Prototype – Video Link

https://youtu.be/flBm4lzZSb4

7.2.3 Working Prototype – Additional Photos

Figure 23 – Internal components

8 DISCUSSION

8.1 DESIGN FOR MANUFACTURING – PART REDESIGN FOR INJECTION MOLDING

8.1.1 Draft Analysis Results

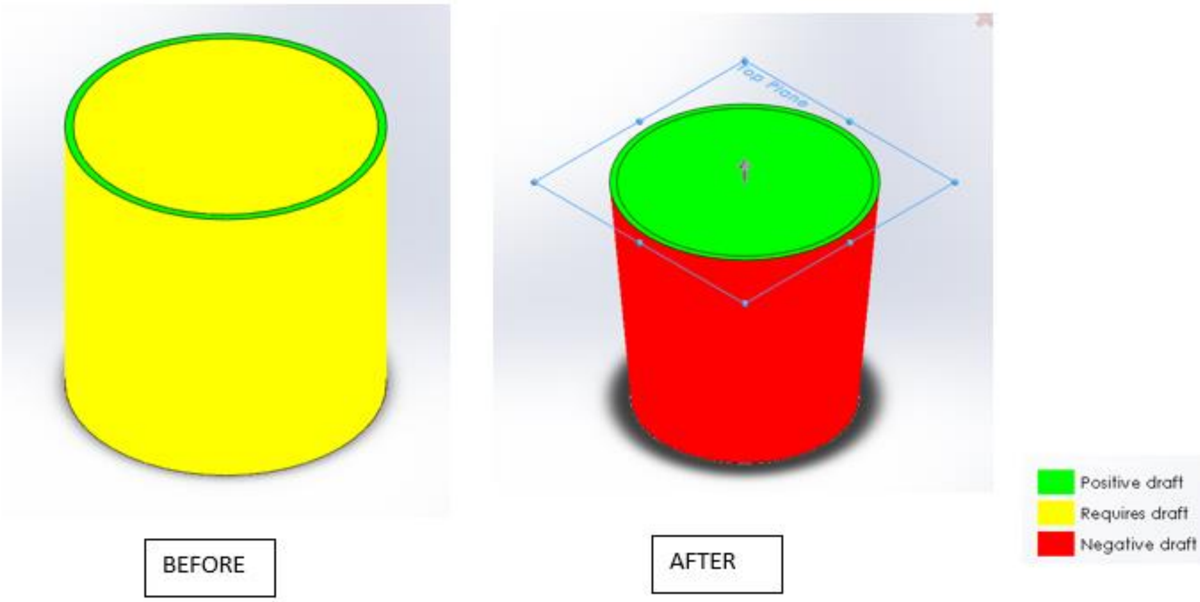


Figure 24 – Draft analysis results showing required drafting

8.1.2 Explanation of Design Changes

This is a draft analysis of our large 5 gallon bucket, as if we had manufactured it. On the left, the "before" drawing shows a completely cylindrical bucket with vertical walls, that requires drafting. To fix this, we applied a 3-degree angle of draft. The "after" drawing shows that the bucket is fixed, as there is a negative draft. This means that if injection molded, the bucket will be removable with minimal damage to the part.

8.2 DESIGN FOR USABILITY – EFFECT OF IMPAIRMENTS ON USABILITY

8.2.1 Vision

A visual impairment such as blindness or having vision impairments would affect the ability to operate the device because our device is not equipped with braille, which would make it difficult.

8.2.2 Hearing

Our device has no audio component, so a hearing impairment would have no significant effect on the usage of the device.

8.2.3 Physical

A person who was under the legal drinking age would be "physically/legally" unable to operate the device because they cannot drink by law. A short person may also have a hard time using the device, if they were not tall enough to reach the top of the device (while on a counter or table) in order to refill the storage containers on the top of the shelf.

8.2.4 Language

With a language impairment the user may have a difficult time distinguishing between drink options, or interpreting warning labels.

8.2 OVERALL EXPERIENCE

8.2.1 Does your final project result align with the initial project description?

Yes, we believe our final project closely matched our initial project description. Although aesthetically some parts were larger, the overall shape and overall project description remained the same throughout our project.

8.2.2 Was the project more or less difficult than you had expected?

The project was as tough as we had predicted. We did a lot of research beforehand about what we would need to accomplish our goals. As a result, we knew that amount of work we had to complete and planned accordingly.

8.2.3 In what ways do you wish your final prototype would have performed better?

I wish the prototype could have been more aesthetically pleasing. Unfortunately, we had time constraints as well as monetary constraints, and as a result we had to sacrifice some of the aesthetics for performance.

8.2.4 Was your group missing any critical information when you evaluated concepts?

No.

8.2.5 Were there additional engineering analyses that could have helped guide your design?

Additional engineering analyses that could have helped guide our design include flow rate analysis. We ran into problems controlling our flow rate, since the tubes would pinch.

8.2.6 How did you identify your most relevant codes and standards and how they influence revision of the design?

We identified our codes and standards by looking up electronic consumer products. We were also given some by Lauren Todd, the engineering librarian. They influenced revision of the design by making sure all components were housed internally, and could not be touched, as it could result in electrical shock.

8.2.7 What ethical considerations (from the Engineering Ethics and Design for Environment seminar) are relevant to your device? How could these considerations be addressed?

Ethical considerations include properly disposing of our materials. For example, we will properly dispose of our batteries so they don't harm the environment. Similarly, we will recycle our plastic tubes and buckets.

8.2.8 On which part(s) of the design process should your group have spent more time? Which parts required less time?

We should have spent more time on the design of the internal components. It took us about two weeks to decide on how we wanted to dispense the liquid, by using valves rather than pumps. The parts that required less time was the construction and assembly.

8.2.9 Was there a task on your Gantt chart that was much harder than expected? Were there any that were much easier?

A task that was much harder than expected was figuring out the internal workings, and the Arduino code. The tasks that were much easier were finding the parts we needed and ordering them.

8.2.10 Was there a component of your prototype that was significantly easier or harder to make/assemble than you expected?

A component that was much easier to make was the external housing, since we found buckets that were suitable. The Arduino portion was much more difficult.

8.2.11 If your budget were increased to 10x its original amount, would your approach have changed? If so, in what specific ways?

Yes. If our budget was 10x as large, we would most likely manufacture our own external housing, use an LED screen for the user to choose their drink, and make it wireless. We could also develop a mobile app to choose your drink, and expand the number of drink containers.

8.2.12 If you were able to take the course again with the same project and group, what would you have done differently the second time around?

We would definitely use stiffer rubber tubes instead of the soft ones. We would also buy higher grade solenoid valves, and think of a different housing compartment with a sliding door, so that it is easier to go in and fix components when necessary.

8.2.13 Were your team member's skills complementary?

Yes, they were. Keegan had worked in a machine shop, so he worked with the wood, cutting it and shaping it. He also assembled the external housing. Alex was good with circuitry, and he made the connections between all the electrical components. I had worked with Arduino before, and had more programming experience, so I focused on the code for the project. We split up responsibilities and worked well as a team.

8.2.14 Was any needed skill missing from the group?

There was a lack of circuitry and programming experience from the team, but we were able to solve that by asking our peers in the engineering school, and looking online.

8.2.15 Has the project enhanced your design skills?

Yes, we all have a better understanding of the engineering design process now, as well as how to manage time on a project. Everything in the course has been very helpful in growing our skills as engineers.

8.2.16 Would you now feel more comfortable accepting a design project assignment at a job?

Yes, I would feel much more comfortable, and I have this great experience to talk about in job interviews as well.

8.2.17 Are there projects you would attempt now that you would not have attempted before?

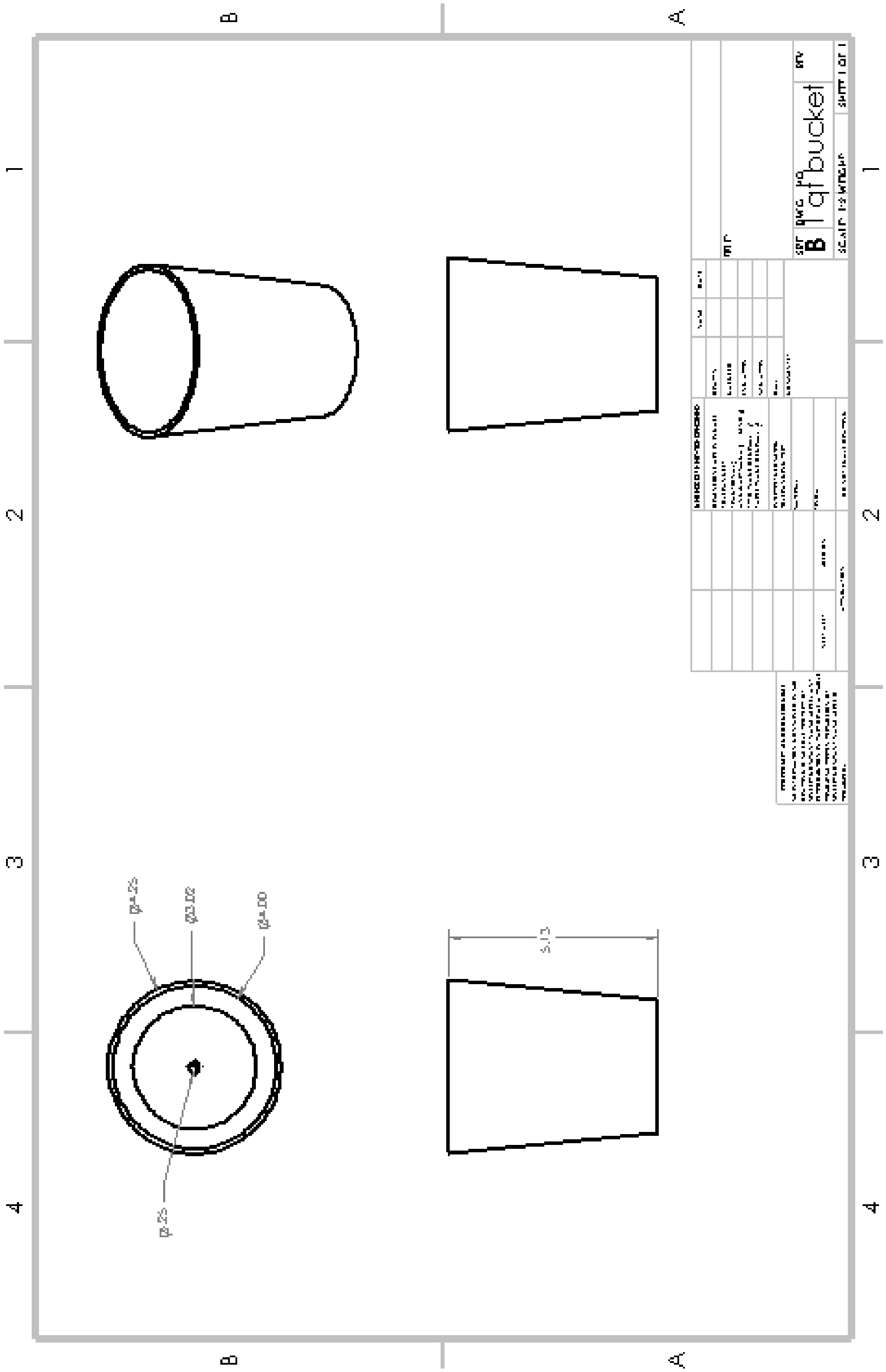
Yes, more complicated projects that involve Arduino, as well as jobs that require circuitry. I have a much better understanding of how valve and tubing systems, so would attempt those projects as well.

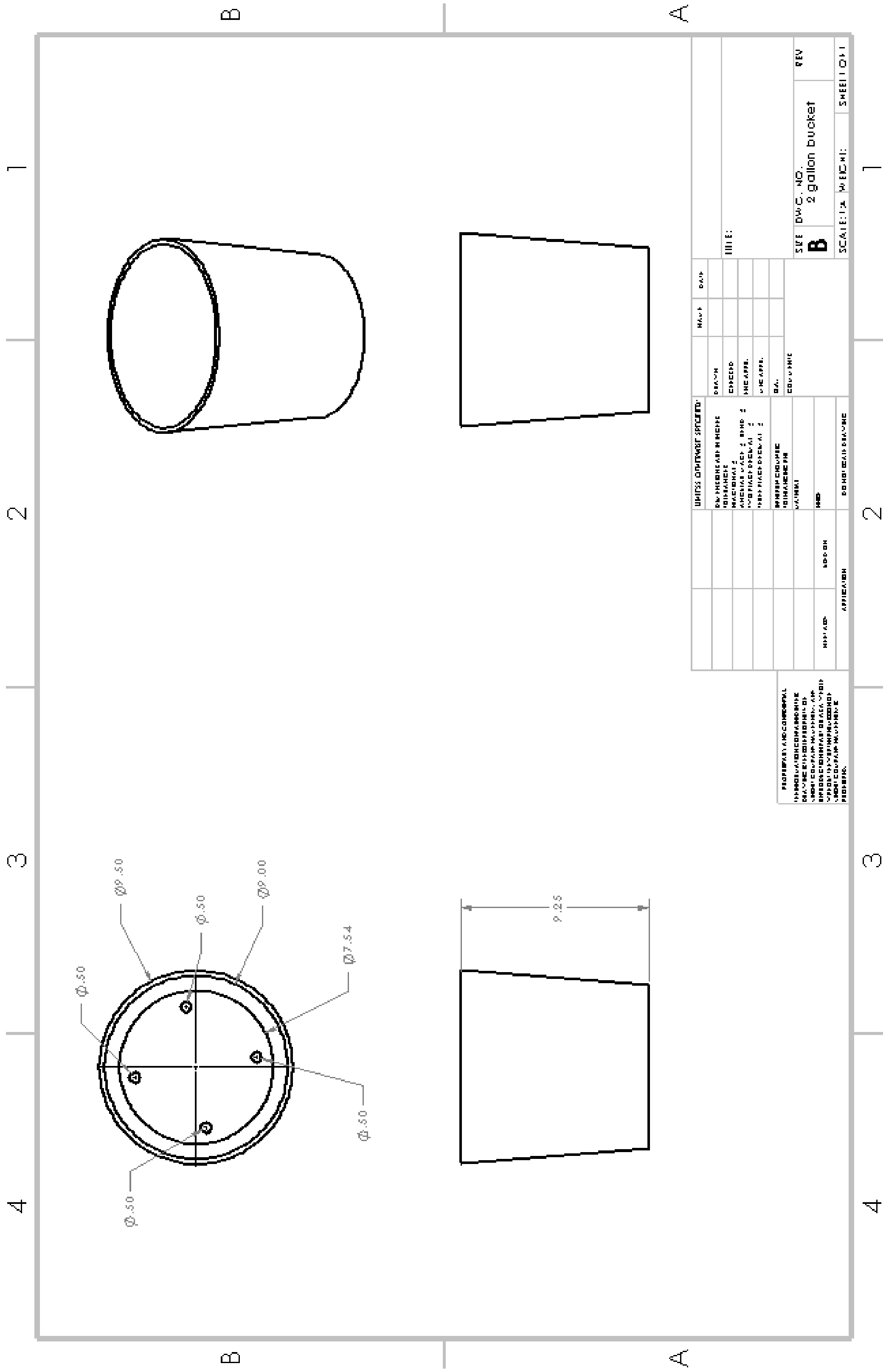
9 APPENDIX A - PARTS LIST

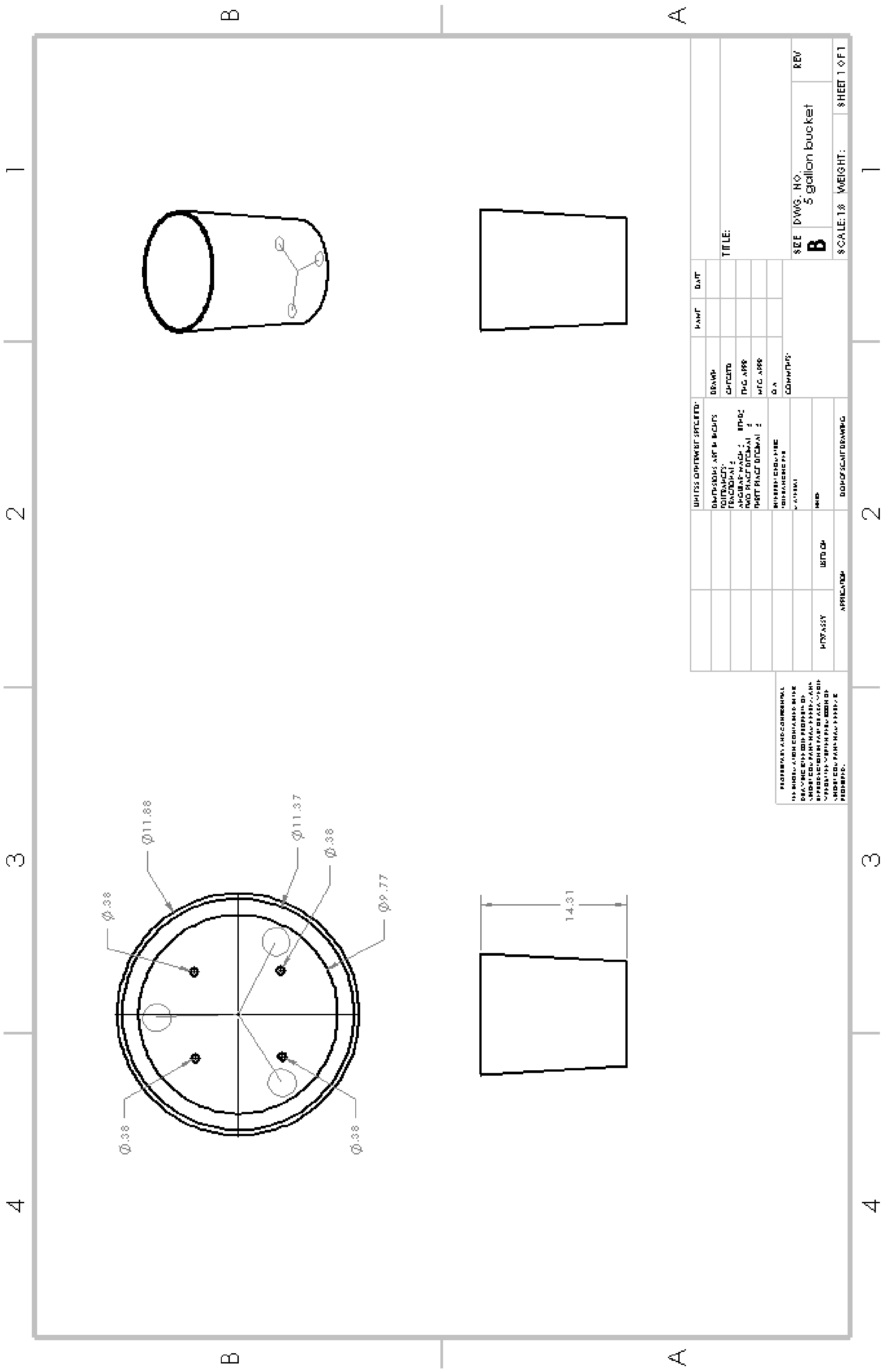
	Part	Source Link	Supplier Part Number	Color, TPI, other part IDs	Unit Price	Tax ($0.00 if tax exemption applied)	Shipping	Quantity	Total Price
1	PVC Tubing for Food, Beverage, and Dairy, 3/16" ID, 1/4" OD	https://www.mcmaster.com/#catalog/123/119/=19s6gmv	5231K952	Clear tubing with nonabsorbing surface	$5.50	$0.00	Unknown	1 (25 feet)	$5.50
2	¼" 12V DC Electric Plastic Solenoid Valve	https://www.electricsolenoidvalves.com/1-4-12v-dc-electric-plastic-solenoid-valve/	RSC-2-12V	Normally closed	$16.99	$0.00	Unknown	4	$67.96
3	Plastic Barbed Tube Fitting for Air and Water	https://www.mcmaster.com/#5372k121/=19s6ibt	5372K121	Semi-Clear White	$4.09	$0.00	Unknown	1 (pack of 10)	$4.09
4	Greartisan DC 12V 60RPM Gear Motor	http://amzn.to/2z2AmAt	B072N84JX7	Pure copper wire core rotor	$12.99	$0.00	$0.00	1	$12.99
5	Tera OldPAPA Stainless Steel Manual Eggbeater	http://amzn.to/2xAUayW	B01E8ND1WS	Stainless steel	$6.99	$0.00	$0.00	1	$6.99
6	Arduino Uno	https://www.amazon.com/Arduino-Uno-R3-Microcontroller-A000066/dp/B008GRTSV6	A000066	Blue	$25.95	$0.00	$0.00	1	$25.95

7	John Guest ¼" x ¼" NPTF Male Value	https://www.h2odistributors.com/ppsv010822w?utm_source=GoogleShopping&utm_campaign=AdWords-Shopping&utm_medium=Product-Ads&gclid=EAIaIQobChMI2vn3ytz61gIVkoZpCh2gPgxTEAQYAyABEgIZcvD_BwE	**PPSV010822W**	White and blue polypropylene – food grade	$4.00	$0.00	$0.00	1	$4.00 (+9.75 shipping)
8	Tolaka Relay Module	https://www.amazon.com/Tolako-Arduino-Indicator-Channel-Official/dp/B00VRUAHLE/ref=pd_sim_147_1?_encoding=UTF8&pd_rd_i=B00VRUAHLE&pd_rd_r=GNKEGKQBQ0A2ZN23NRWM&pd_rd_w=l0mni&pd_rd_wg=xHl81&psc=1&refRID=GNKEGKQBQ0A2ZN23NRWM	AVR MCU	Blue	$5.80	$0.00	$0.00	5	$29
Total:									$156.48

10 APPENDIX B - CAD MODELS


1qtbucket


Ø9.50
Ø.50
Ø9.00
Ø7.54
Ø.50
Ø.50
Ø.50
9.25
2 gallon bucket


TITLE:
SIZE
B
DWG. NO.
5 gallon bucket
REV
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
14.31
Ø11.88
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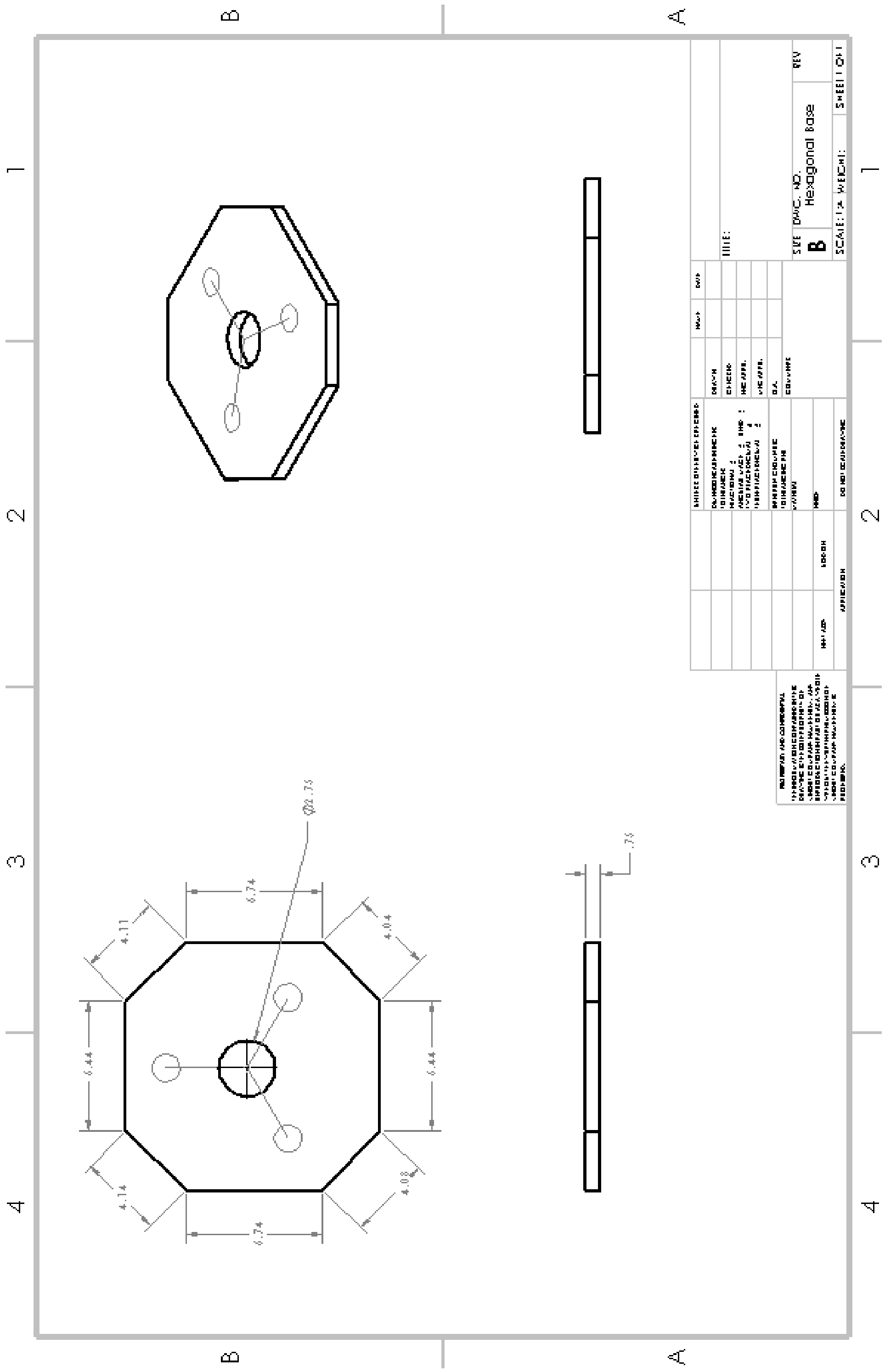
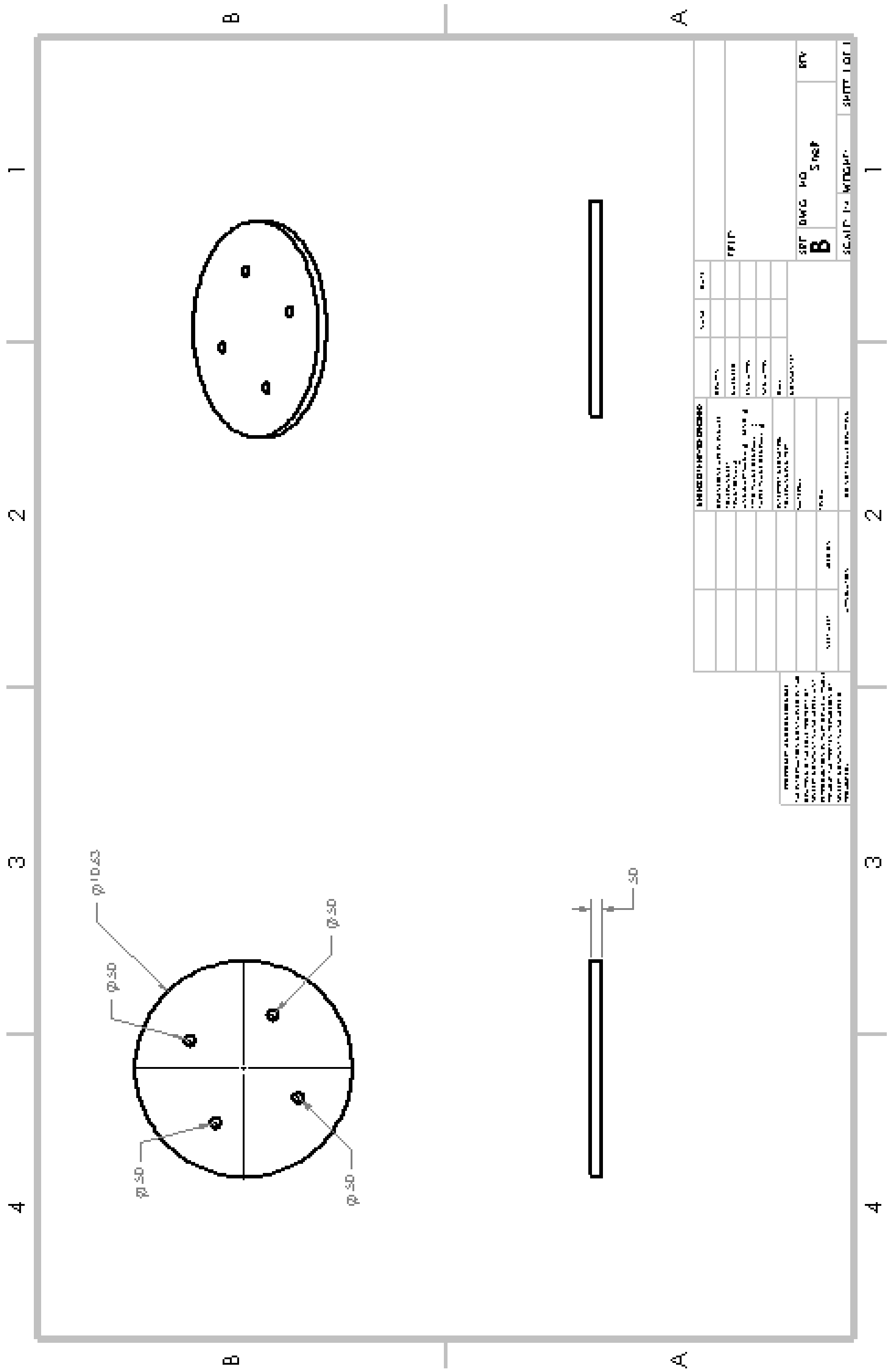
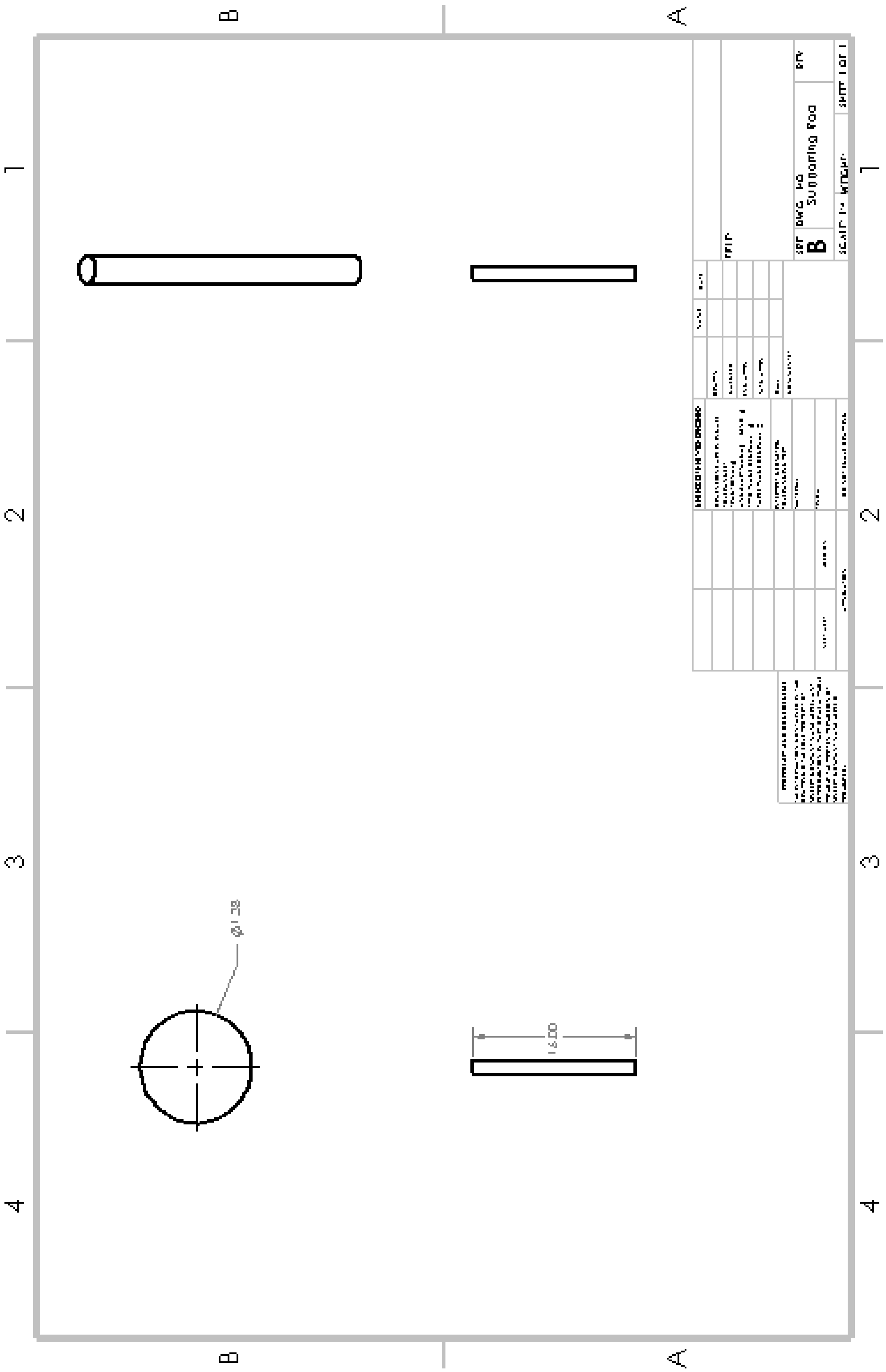
Ø.38


Hexagonal Base




Supporting Rod

11 APPENDIX C - ANNOTATED BIBLIOGRAPHY

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[2] jts3k, and Instructables. “Controlling Solenoids With Arduino.” *Instructables.com*, Instructables, 5 Nov. 2017, www.instructables.com/id/Controlling-solenoids-with-arduino/.

[3] Love, Dylan. “We Really Want A Barobot, The Automatic Cocktail-Mixing Robot Raising Money On Kickstarter Right Now.” *Business Insider*, Business Insider, 22 May 2014, www.businessinsider.com/barobot-cocktail-robot-2014-5.

[4] “McMaster-Carr.” *McMaster-Carr*, www.mcmaster.com/.

[5] “Portable Smartender.” *Smart Bar USA*, smartbarusa.com/portable-smartender.

[6] “US20060118581A1 - Apparatus for Automatically Dispensing Single or Mixed Drinks.”*Google Patents*, Google, patents.google.com/patent/US20060118581A1/en.

[7] “US6607013B1 - Automatic Bar.” *Google Patents*, Google, patents.google.com/patent/US6607013B1/en.