Washington University in St. Louis

Washington University Open Scholarship

Washington University / UMSL Mechanical Engineering Design Project JME 4110

Mechanical Engineering & Materials Science

Summer 8-12-2019

JME 4110 Mechanical Engineering Design Project:Stir It Up

Josephn Biermann
Washington University in St. Louis, jbiermann@wustl.edu

Brittany Gray
Washington University in St. Louis, b.gray@wustl.edu

Nathan Hopper
Washington University in St. Louis, n.hopper@wustl.edu

Follow this and additional works at: https://openscholarship.wustl.edu/jme410

Part of the Mechanical Engineering Commons

Recommended Citation

Biermann, Josephn; Gray, Brittany; and Hopper, Nathan, "JME 4110 Mechanical Engineering Design Project:Stir It Up" (2019). *Washington University / UMSL Mechanical Engineering Design Project JME 4110*. 25.
https://openscholarship.wustl.edu/jme410/25

This Final Report is brought to you for free and open access by the Mechanical Engineering & Materials Science at Washington University Open Scholarship. It has been accepted for inclusion in Washington University / UMSL Mechanical Engineering Design Project JME 4110 by an authorized administrator of Washington University Open Scholarship. For more information, please contact digital@wumail.wustl.edu.

Joint Engineering Program

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

ELEVATE YOUR FUTURE.
ELEVATE ST. LOUIS.

We are designing and building a working prototype that will be able to mix a separated beverage back to a fully integrated state. This will allow for mixing in a beverage that was separated and would possibly just be thrown away because it doesn't taste right anymore. This will save food waste from separated beverages being thrown away as well as be environmentally friendly since it would reduce the use of single use cups and straws.

JME 4110
Mechanical Engineering
Design Project

Stir It Up

Joseph Biermann
Brittany Gray
Nathan Hopper

Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

1.1 VALUE PROPOSITION/PROJECT SUGGESTION

We are designing and building a working prototype that will be able to mix a separated beverage back to a fully integrated state. This will allow for mixing in a beverage that was separated and would possibly just be thrown away because it doesn't taste right anymore. This will save food waste from separated beverages being thrown away as well as be environmentally friendly since it would reduce the use of single use cups and straws as the cups / cup accessories that we design will be reusable. Our target market would be individual shoppers who like smoothies, being eco-friendly, and not wasting food. There will be labor, material and production costs (if mass produced) involved, not to exceed $400 for the initial item.

1.2 LIST OF TEAM MEMBERS

Joe Biermann

Brittany Gray

Nathan Hopper

2 BACKGROUND INFORMATION STUDY

2.1 DESIGN BRIEF

"Stir It Up" is our project name. We are designing and building a working prototype that will be able to mix a separated beverage back to a fully integrated state.

Purpose and Need – This will allow for mixing in a beverage that was separated and would possibly just be thrown away because it doesn't taste right anymore.

Business Drivers and Significance – This will save food waste from separated beverages being thrown away. It will also be eco-friendly as the cups / cup accessories will be reusable.

Benefits and Costs – Saves food waste, plastic waste, and creates profits and goodwill. There will be labor, material and production costs (if mass produced)

2.2 BACKGROUND SUMMARY

thinkgeek.com/product/cf68

This product is fairly similar to the one that we are trying to create. This system is operated based upon a rotating fan like blade at the bottom of the cup. Pressing the button rotates the blade like device and mixes the cup, however it stops once the button isn't pressed. We want our design to not be as dangerous and to be consistently spinning in the bottom of our cup.

3 CONCEPT DESIGN AND SELECTION

3.1 USER NEEDS AND METRICS

3.1.1 Record of the user needs interview

Q: Overview of the problem

A: Need to be able to mix up separated smoothies, but not limited to that field. There could be applications in other fields. Would be nice if it was something cool for the kids to watch like the fascination with the self-stirring mug.

Q: Does it need to have travel capabilities?

A: Should be portable, then could be taken with you to your favorite smoothie place.

Q: Would you be okay with bringing your own cup to the smoothie place?

A: Not opposed to putting in a different cup, but not enthusiastic about it. Not likely to use if fingers will get smoothie on them.

Q: What are some characteristics or features that you would like to see?

A: Portable, dishwasher friendly and minimal disassembly required for washing, can work for a variety of drink sizes (16oz-32oz), doesn't want to touch smoothie product.

Q: How much are you willing to pay for a perfect solution?

A: $5-$10 given the niche, but for one time use solutions probably around 50 cents each.

Q: Are you sensitive to changes to the cup itself?

A: Fundamentally should be a cup, ok if it has an option to close the cup, could be layered with an inner sleeve for mixing.

3.1.2 List of identified metrics

Metric Number	Associated Needs	Metric	Units	Min Value	Max Value
1	1	Design Fascinating	Binary	0	1
2	2	Portable	Binary	0	1
3	3	Dishwasher Friendly	Binary	0	1
4	4	Minimal Parts	Integer	2	10
5	5	Fits variety of sizes	Fluid Ounces	16	32
6	6	Price Point	Dollars	5	10
7	7	Mess-free use	Binary	0	1
8	8	Number of Decibels (noise level)	Integer	50	80
			Inches	15	30
9	9	Ability to mix smoothie	Percentage	0	100

Table 1: Metrics for Stir It Up

3.1.3 Table/list of quantified needs equations

Need Number	Need	Importance
1	SIU needs to be fascinating	3
2	SIU needs to be portable	5
3	SIU needs to be dishwasher friendly	5
4	SIU needs to have minimal disassembly	4
5	SIU needs to fit a variety of drink sizes	5
6	SIU needs to be in the price range of $5-$10	5
7	SIU needs to keep hands mess free	4
8	SIU doesn't need to extremely quiet	1
9	SIU needs to be able to fully mix a drink	5

Table 2: Needs for Stir It Up

3.2 CONCEPT DRAWINGS

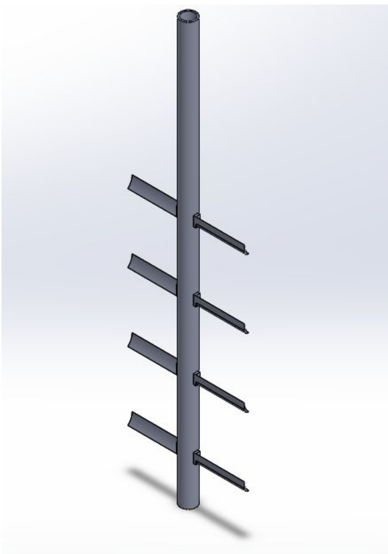


Figure 1: Concept 1

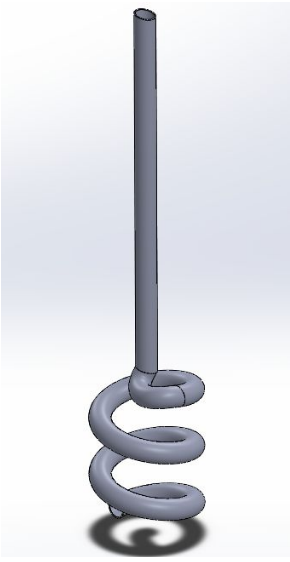


Figure 2: Concept 2

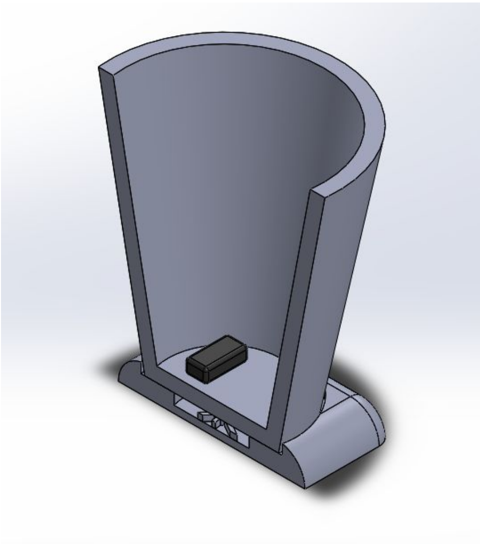


Figure 3: Concept 3

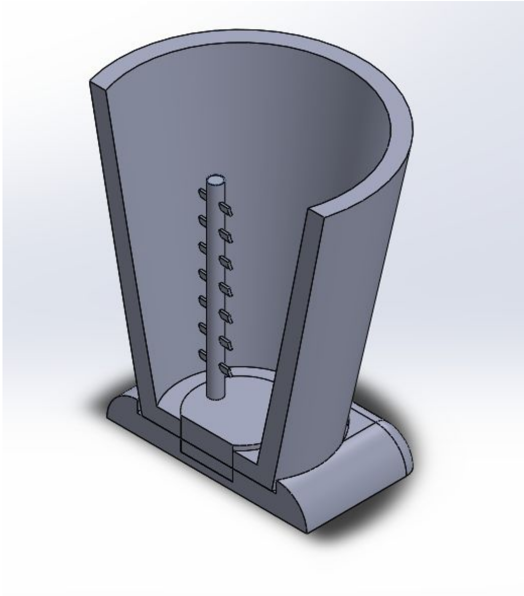


Figure 4: Concept 4

3.3 CONCEPT SELECTION PROCESS

3.3.1 Concept scoring (not screening)

	Personal Smoothie Mixer Cup	Metric															
		Design Fascinating	Portable	Dishwasher friendly	Number of parts	Fluid ounces	Price	Clean fingers	Number of Decibels	Mixture Percentage	Metric 10	Metric 11	Metric 12	Metric 13	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	10	11	12	13			
1	Has a fascinating design	1													1	0.08	0.08
2	Be able to use on the go		1												1	0.14	0.14
3	Able to be cleaned in the dishwasher			1											0	0.14	0
4	Have minimal parts to take apart for cleaning				1										1	0.11	0.11
5	Can handle a variety of drink sizes					1									0.5	0.14	0.07
6	Low price point for reusable						1								0.8	0.14	0.112
7	Design keeps fingers clean							1							1	0.11	0.11
8	Noise level								1						1	0.03	0.03
9	Ability to fully Remix drink									1					1	0.14	0.14
10	Need 10														0	0	0
11	Need 11														0	0	0
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Binary	Binary	Binary	Integer	Fl. Oz	Dollars	Binary	Integer	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.792
Best Value		1	1	1	2	32	5	1	50	100							
Worst Value		0	0	0	10	16	10	0	80	0							
Actual Value		1	1	0	2	24	6	1	50	100							
Normalized Metric Happiness		1	1	0	1	0.5	0.8	1	1	1							

Table 3: Concept Scoring for Concept 1

Example Template		Metric															
		Design Fascinating	Portable	Dishwasher friendly	Number of parts	Fluid ounces	Price	Clean fingers	Number of Decibels	Metric 9	Metric 10	Metric 11	Metric 12	Metric 13	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	10	11	12	13			
1	Has a fascinating design	1													1	0.09	0.09
2	Be able to use on the go		1												1	0.16	0.16
3	Able to be cleaned in the dishwasher			1											1	0.16	0.16
4	Have minimal parts to take apart for cleaning				1										1.25	0.13	0.1625
5	Can handle a variety of drink sizes					1									-1	0.16	-0.16
6	Low price point for reusable						1								2	0.16	0.32
7	Design keeps fingers clean							1							0	0.13	0
8	Noise level								1						2.66666666	0.03	0.08
9	Need 9														0	0	0
10	Need 10														0	0	0
11	Need 11														0	0	0
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Binary	Binary	Binary	Integer	Fl. Oz	Dollars	Binary	Integer	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.8125
Best Value		1	1	1	2	32	5	1	50								
Worst Value		0	0	0	10	16	10	0	80								
Actual Value																	
Normalized Metric Happiness		1	1	1	1.25	-1	2	0	2.666666667								

Table 4: Concept Scoring for Concept 2

Example Template		Metric															
		Design Fascinating	Portable	Dishwasher friendly	Number of parts	Fluid ounces	Price	Clean fingers	Number of Decibels	Metric 9	Metric 10	Metric 11	Metric 12	Metric 13	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	10	11	12	13			
1	Has a fascinating design	1													1	0.09	0.09
2	Be able to use on the go		1												1	0.16	0.16
3	Able to be cleaned in the dishwasher			1											1	0.16	0.16
4	Have minimal parts to take apart for cleaning				1										1.25	0.13	0.1625
5	Can handle a variety of drink sizes					1									-1	0.16	-0.16
6	Low price point for reusable						1								2	0.16	0.32
7	Design keeps fingers clean							1							0	0.13	0
8	Noise level								1						2.66666666	0.03	0.08
9	Need 9														0	0	0
10	Need 10														0	0	0
11	Need 11														0	0	0
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Binary	Binary	Binary	Integer	Fl. Oz	Dollars	Binary	Integer	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.8125
Best Value		1	1	1	2	32	5	1	50								
Worst Value		0	0	0	10	16	10	0	80								
Actual Value																	
Normalized Metric Happiness		1	1	1	1.25	-1	2	0	2.666666667								

Table 5: Concept Scoring for Concept 3

Example Template		Metric: Design Fascinating	Portable	Dishwasher friendly	Number of parts	Fluid ounces	Price	Clean fingers	Number of Decibels	Metric 9	Metric 10	Metric 11	Metric 12	Metric 13	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	10	11	12	13			
1	Has a fascinating design	1													1	0.09	0.09
2	Be able to use on the go		1												1	0.16	0.16
3	Able to be cleaned in the dishwasher			1											1	0.16	0.16
4	Have minimal parts to take apart for cleaning				1										1.25	0.13	0.1625
5	Can handle a variety of drink sizes					1									-1	0.16	-0.16
6	Low price point for reusable						1								2	0.16	0.32
7	Design keeps fingers clean							1							0	0.13	0
8	Noise level								1						2.66666666	0.03	0.08
9	Need 9														0	0	0
10	Need 10														0	0	0
11	Need 11														0	0	0
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Binary	Binary	Binary	Integer	Fl. Oz	Dollars	Binary	Integer	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.8125
Best Value		1	1	1	2	32	5	1	50								
Worst Value		0	0	0	10	16	10	0	80								
Actual Value																	
Normalized Metric Happiness		1	1	1	1.25	-1	2	0	2.666666667								

Table 6: Concept Scoring for Concept 4

3.3.2 Preliminary analysis of each concept's physical feasibility

1. The first design is the Straw with bars design. This design would work well in mixing a drink back to its original state, however it seems a bit impractical. I don't really think a consumer would bring along a case with three to four rods and assemble their straw in order to mix their drink together. The only other special requirement for this would be designing a straw with slits in the sides for the bars to slide into place in order to mix the drinks. These slits would have to be tight around the bars in order for suction to be used to bring liquid or slushie to the user.

2. The second design is the Corkscrew Straw. This design is a little less impractical, as you just have to place the straw in the lid and then the lid onto the cup, but probably would not get the job done. This would not be enough of a difference over an ordinary straw. The slushie would not be mixed enough. There is no special requirements for this design.

3. The third design is the Metal Mixer, this seems both practical and like it would get the job done. The rotating metal bar at the bottom of our cup would mix the drink close to what it was originally, it might not be perfect, but it will get us the closest. The special requirement for this design would be that it would need to be electrical.

4. The fourth and final design we came up with was the Personal Smoothie Mixer Cup. This one seems wildly impractical, but it would get the job done. This design would mix the drink up the best, but it would come at a cost. The special requirement for this design would be a much higher input of energy and a bigger motor than the Metal Mixer.

3.3.3 Final summary statement

The Metal Mixer was one of our first designs that we came up with. It comes with a wow factor, in that when turned on you can see the metal bar rotating in the bottom and see the drink being mixed up. Our other designs had a bit of a fascinating approach, but this was by far the best one visually. We came to the conclusion with the Straw with Bars that the design would be pretty difficult to pull off. We would have to design a straw that had slits down the sides so that the bars could slide through. We needed the slits to be almost the perfect size to maintain suction throughout the straw as the drink became depleted. We came to the conclusion that this would not work. The Corkscrew Straw was a relatively neat design in that it could sell to little kids, but once we really took an in depth look at whether or not it could actually mix drinks well, we came to the conclusion that it would not. The Personal Smoothie Mixer Cup failed because it would require too high of a motor. This would also be a very specific cup size. We wanted our design to fit any cup size that was available, or at least as many as we could. The Personal Smoothie Mixer Cup would have to come with its own specific cup. What we think was the perfect fit was the Metal Mixer. The Metal Mixer like stated earlier comes with a fascinating design. It also comes in any size cup, as long as you can open the lid and the metal bar fits at the bottom this will be universal. Another main reason it won was because it is incredibly easy to clean, all you need to do is throw the bar in a dish washer and wipe down the coaster it sits on. The noise level will be at minimum and, as far as we can tell, this seems relatively inexpensive. In short, the fascinating design, portability, dishwasher safe, variety of drink sizes, low price, and noise levels of the Metal Mixer are all the reasons why it outshined our other designs and inevitably was the winner.

3.4 PROPOSED PERFORMANCE MEASURES FOR THE DESIGN

Our main performance measure is if the separated smoothie is able to be mixed back in with our product.

3.5 REVISION OF SPECIFICATIONS AFTER CONCEPT SELECTION

We originally wanted to have the base be circular so that it could fit in a car cup holder, but we had to change that due to the size of the base to fit the square fan casing. Also, the fan base would be too tall to sit in a cup holder and keep the cup from falling over. We changed the design to have a square base to better fit with our design components.

4 EMBODIMENT AND FABRICATION PLAN

4.1 EMBODIMENT/ASSEMBLY DRAWING

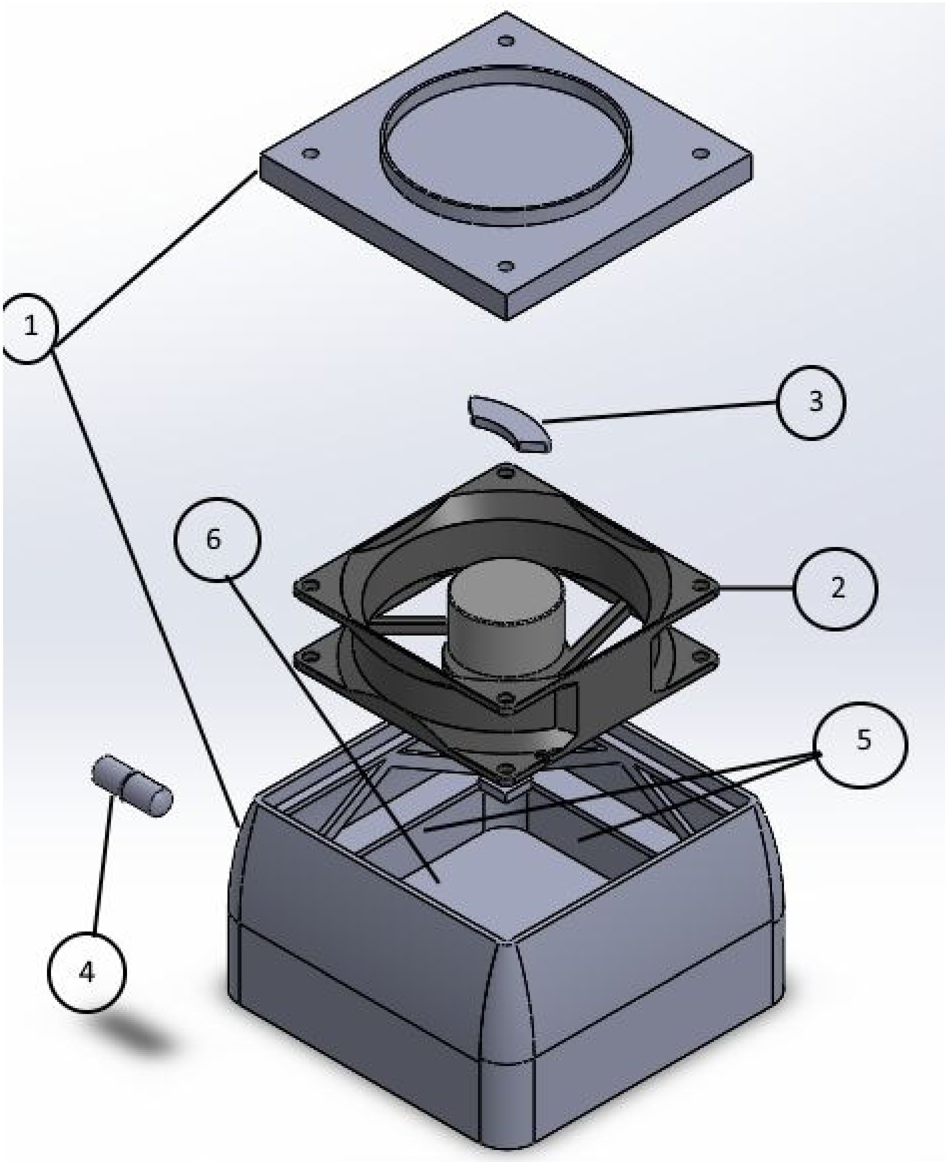


Figure 5: Initial Assembly Drawing

4.2 PARTS LIST

1. Outer Case – this will be 3D printed by us in lab (Per Louis, price is almost negligible as the plastic is so cheap)
2. Small 60 mm motorized computer fan – We have a few extra sitting around that we can use, but if we had to price them, Newegg has 60mm fans for $4.50
3. Magnet – Hard drive magnet (Ebay 12 for $8.50 = $0.71 each)(already bought them)
4. PTFE coated magnet bar (Approximately $1.00 each on Amazon) (We plan to buy the 10 bar set with retriever wand for $19.99)

5. 2 X Battery Housing for 2 AA batteries – (Keystone Electronics - $1.153 each- if we buy 10, they are $1.121)
6. Foam - (Can use weather seal – Grainger Weather Seal 42" H, 1-1/4' W - $0.95 each)

4.3 DRAFT DETAIL DRAWINGS FOR EACH MANUFACTURED PART

This is the design for the 3D printed base. It's the top, bottom and sides of the base. The sectional view shows the fan as well, which we will not be 3D printing.

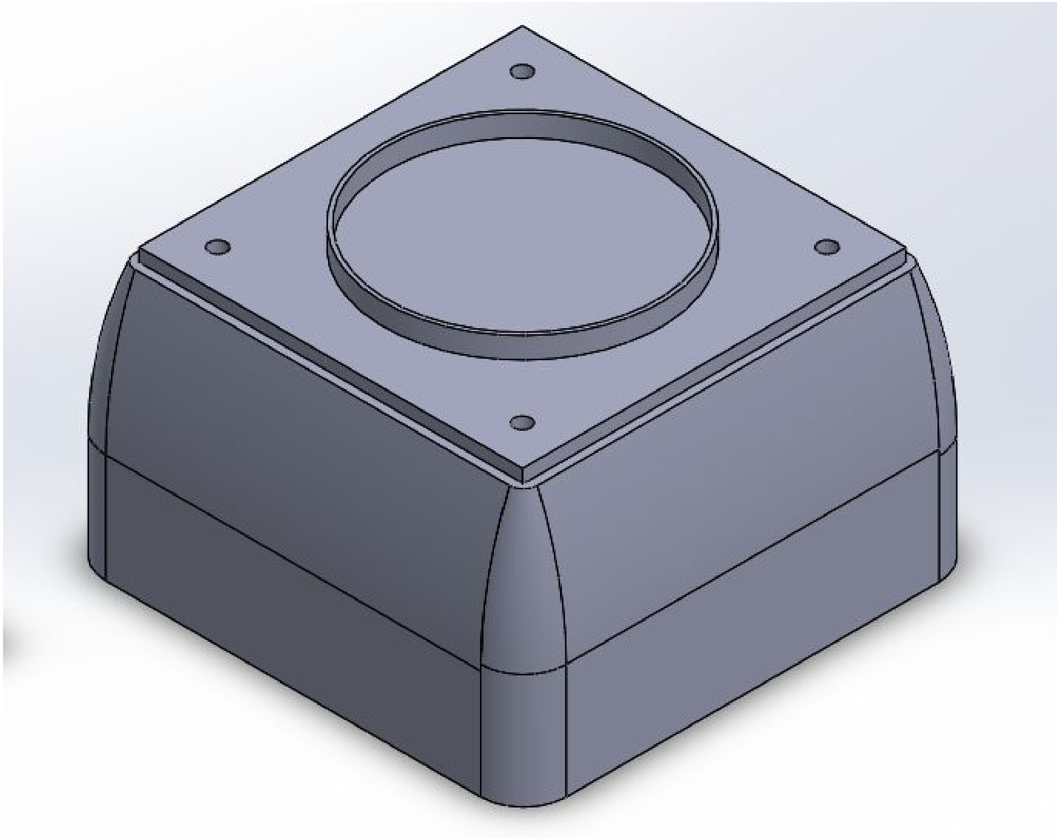


Figure 6: Drawing of 3D printed base

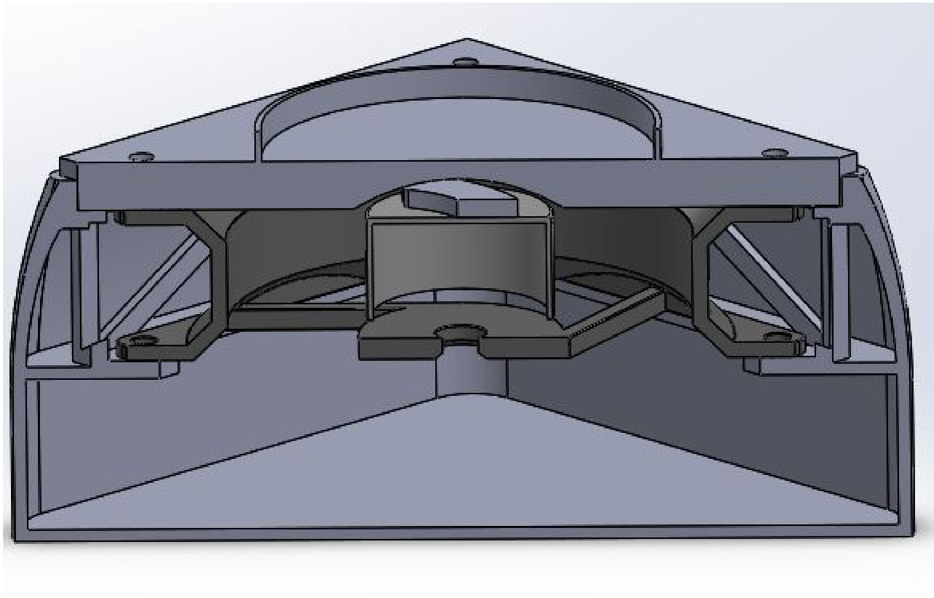


Figure 7: Sectional view of 3D printed base

4.4 DESCRIPTION OF THE DESIGN RATIONALE

We had to take into consideration the size of the battery packs to make sure there was enough room in the base to fit the battery housing. We wanted the top base to be big enough to fit the average size cup and the bottom of the base big enough to supply stability for the internal movement of the stirrer without being knocked over. Hard drive magnets were selected due to their strength and already semi-circular shape. This should make them easier to balance internally and they are a good size for our design. The small internal computer cooling fan should keep the weight down and allow for less noise. Originally, we wanted to go with a round design to fit in the average automobile cup holder. However after further review, we didn't think we could make the coaster work in the way we wanted with that small amount of space as the average car cup holder is less than 3 inches in diameter. We wanted the magnetic bar to have some sort of coating to keep it from giving the drink a metallic taste, so we went with PTFE coating. The foam is to reduce internal movement in the coaster/base and to help with noise reduction, reducing any possible rattling.

For mass production, we would want to try to fabricate as many parts as possible. PTFE coated magnetic bars would be easy to do since we could buy a long bar of the magnetic metal. Those could be cut down to size and coated with PTFE. The small motorized fan would be more complicated to fabricate, so we would probably be better off just sourcing those parts from another company as it may not be worth the costs for buying and maintaining the machinery. The outer case could easily be fabricated from molds, which would be ideal for mass production as the 3D printing process is more lengthy.

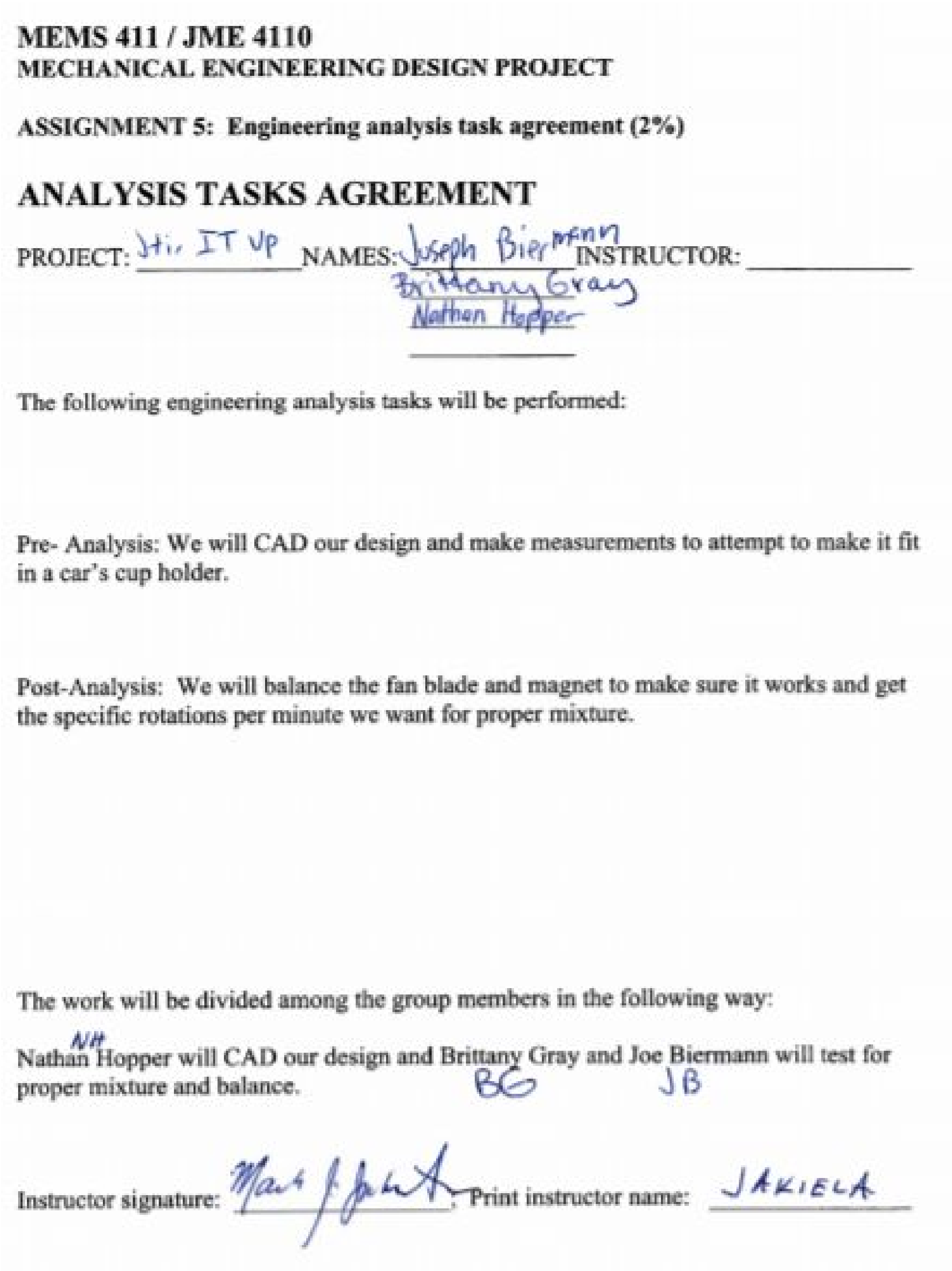
For our prototype, we will be using mostly pre-existing parts/materials since we don't have a budget to create molds/machinery to build from raw materials.

5 ENGINEERING ANALYSIS

5.1 ENGINEERING ANALYSIS PROPOSAL

To CAD our design to attempt to make it fit in a car's cup holder. We will balance the fan blade and magnet to make sure it works properly to get the correct number for rotations for proper mixture.

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: Stir IT Up NAMES: Joseph Biermann, Brittany Gray, Nathan Hopper INSTRUCTOR: ____________

The following engineering analysis tasks will be performed:

Pre- Analysis: We will CAD our design and make measurements to attempt to make it fit in a car's cup holder.

Post-Analysis: We will balance the fan blade and magnet to make sure it works and get the specific rotations per minute we want for proper mixture.

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

Nathan Hopper (NH) will CAD our design and Brittany Gray (BG) and Joe Biermann (JB) will test for proper mixture and balance.

Instructor signature: [signature] Print instructor name: JAKIELA

Figure 8: Signed Engineering Analysis Agreement

5.2 ENGINEERING ANALYSIS RESULTS

5.2.1 Motivation

Our primary points of analysis are the sizing of our coaster, the proper balance of the fan and magnet, and the amount of rotations per minute for our metal bar. We specifically wanted our coaster to be as small as possible so that the consumer could transport it wherever they go. Another goal of ours was to make it so that the coaster could fit in a car's cupholder. This would be ideal, however if it doesn't work out, it won't be a design damaging flaw. The second analysis is the proper balance of the fan and magnet. Our computer fan in our design is extremely fragile, we will have to do a lot of balancing in order to get our magnet to not only sit right, but also to rotate correctly. Our last major analysis is the rotations per minute for our metal bar. We have to have the right rotations per minute of our metal bar in order for our mixture to be properly mixed, too fast could cause our liquid to go flying, too slow and our mixture will not be properly mixed.

5.2.2 Summary statement of analysis done

The analysis that we did for the sizing was fairly simple. We organized the exact parts that we were going to use for our design and sized them out. Then we created a CAD assembly sizing out our coaster and then used the measurements from the average car cupholder to see if we could design it in order for it to fit. The analysis for the balancing of the magnet and computer fan was a bit more difficult. The balancing was mainly trial and error. We cut the fans blades so that it had a more centralized focus. Then we placed the magnet on the fan with tape, so that it wasn't permanently on the fan and ran the system, we moved the magnet around until the fan worked properly and then glued the magnet on to the fan in the desired location. Our final analysis was also trial and error. We tested our design after the magnet was permanently placed on milk shakes, we chose milkshakes because they are very thick, and we knew everything we wanted to mix properly would not be as thick. We let a couple of milkshakes sit for a while in a refrigerator and then varied the rotations per minute on each one examined them and picked the milkshake, we thought worked the best. After this we then tested it again on Slurpee's and protein shake to make sure they mixed properly.

5.2.3 Methodology

Our main experiments that we used to design our design was the two trial and error tests. The two trial and error tests were the balancing of the magnet and fan, where we taped the magnet on and ran it until our fan worked properly, and the rotations per minute for our metal bar in our drink. The first one was just trial and error until our fan worked properly. The second experiment was a little more user driven. We knew we didn't just want a single speed on our design, and we wanted an option to have a range on speeds. We basically ran our test prototype at the max and then scaled down our speed until we were happy with the maximum, and then we ran it multiple times until we were satisfied with the slowest possible speed that still just barely mixed the milkshake. Our test rig was just a very barebones version of our design with a very basic shell for our coaster. There wasn't that much computation, this was graded on sight and the mixture percentage.

5.2.4 Results

Our CAD design showed some unwanted results. There just was no way, with everything that we needed, to design our coaster so that it could fit into the average cup holder. Our coaster would be too high and the risk of the cup falling out would be too great in order for this to be a key feature. The other two experiments gave us the results that we wanted. We were able to get the magnet on the fan and have the fan function properly. We also achieved a satisfactory minimum speed and a proper maximum speed for our rotations per minute of our metal bar. One problem that we did run into as well with the Rotations per minute experiment was the stirring bar was not big enough. It didn't stir the right way and didn't mix very well, we decided to get a bigger size stir rod and it seemed to work fine.

5.2.5 Significance

Our main design change that came from the experiments was from the sizing in the CAD drawing. We originally designed it so that we could fit it into the average car's cupholder. With this being a main feature, our initial designs were a rounded coaster. Seeing as there was no way for it to properly fit in the cupholder without the cup tipping out, we decided to go from a circular base to a square base. This allowed us to use a lot more room for the parts in our coaster and allowed us to shrink the size down a bit. This basically changed our entire design, allowing our coaster to be much more portable and smaller in size. The other two experiments were performance based. Those did not affect the design of our coaster all that much. The only really tiny design change that occurred out of the rotations per minute experiment was that we confirmed that we needed a second set of batteries to operate our device. This didn't really change our design all that much as we designed it with two sets of two battery ports, but it did confirm our need for them. As mentioned before we did get a bigger stir rod because of the failure to mix on the first attempt.

6 RISK ASSESSMENT

6.1 RISK IDENTIFICATION

A group brainstorming session was held at the beginning of the project to determine all possible risks involved in the project. This session yielded the following risks:

- Parts delays, either availability of needed parts or could be damaged on delivery
- Printing problems with 3D printed parts
- 3D printer availability
- Swallowing the magnet bar
- Magnet interfering with electronics in fan
- Magnet unbalancing fan, not allowing for movement
- Magnet being unable to stir drink
- Losing magnetic connection between stirrer bar and fan magnet
- Entire device not fitting in cupholder
- Air resistance from fan blades dampening fan motion
- Rattling from fan might cause movement and knock over cup

6.2 RISK ANALYSIS

Of the list of risks generated by our group, many of these were testable in post production. Once tested, design changes could occur to either remove or lessen the effects of these risks, either in the design of the stirrer itself or in changes to the parts ordered. Other risks coming from outside our design, such as the delay in acquiring parts, would delay our prototyping schedule in a way that would be outside of our control.

6.3 RISK PRIORITIZATION

After analyzing all possible risks involved in this project, our group determined the following risks of highest priority:

- Device being too tall for a car cupholder
- Magnet being unable to stir drink
- Parts delays

7 CODES AND STANDARDS

1. Benson, L. and Reczek, K. (2016). *A Guide to United States Electrical and Electronic Equipment Compliance Requirements*.
2. Guide to Standards - Household Electrical Equipment. (n.d.). Sai Global.
3. Standard Specification for Additive Manufacturing File Format (AMF) Version 1.2. (n.d.). ASTM International.
4. Standard Specification for Polytetrafluorethylene (PTFE) Resin Molded Sheet and Molded Basic Shapes. (n.d.). ASTM International.

7.1 IDENTIFICATION

These are the most relevant codes because we are using PTFE coated stirrer bars in our design. We will also be 3D printing parts, which is where the additive manufacturing standards come in. We pulled 2 different documents on electrical components for small appliances. One is specifically for Australia but Lauren said our budget was running low and provided what she could for us. Maybe we'll plan on expanding into the Australian market once our product is a huge success in the USA.

7.2 JUSTIFICATION

These codes / standards didn't really constrain any of our design. Everything that we were planning on including design wise already falls within the codes. Our electrical wiring has to be safe and not faulty, but that is already part of the plan as no one wants to be shocked.

7.3 DESIGN CONSTRAINTS

Our final prototype isn't highly influenced by these codes, as we were already thinking clearly about a responsible design that won't run the risk of harming anyone. It doesn't change anything on our CAD model as all of our specifications fall within safe parameters. We also have experience in 3D printing from taking Advanced CAD and are aware of the limitations of the software and what we can do with it.

8 WORKING PROTOTYPE

8.1 PROTOTYPE PHOTOS

This picture below is our entire design. In this picture you can see the top of our base is attached sitting in its position. Our mixing bar is sitting on the top of our lid. The lid is removable but needs to be in place in order for our invention to work. The back of our base has our wiring hanging out of it and the switch is sitting at the base, it has Off, Low, Medium, and High settings.

Figure 9 : Base with top

Our second picture is without the lid on our base. The lid is sitting at the top there with the mixing bar on the top. The magnet is attached to the center of the fan but not directly on the center so that the mixing bar can still spin.

Figure 10 : Base without top

8.2 WORKING PROTOTYPE VIDEO

https://youtu.be/U642oh4oFoU

8.3 PROTOTYPE COMPONENTS

Figure 11: Mixing Bar

Figure 11 shows the mixing bar. You simply place this into your cup and put the cup on top of our coaster. Once the coaster is turned on the mixing bar will spin and mix the drink.

Figure 12: Fan with Magnet

This image displays our fan and magnet. When the switch is turned on our fan will rotate, rotating our magnet which will then in turn rotate our mixing bar and mix our drink. We initially debated cutting the blades off the fan to remove a source of air resistance, but we decided to retain them in the end as it helped balance the system.

Figure 13: Switch

Figure 13 shows the switch for our machine. There are four settings four our system. The 'O' is the off setting, the 'L' is for the lowest speed, the 'M' is the medium speed, and the 'H' is the highest speed. The highest setting would typically be used for bigger drinks and thicker drinks.

Figure 14: Base Top

Figure 14 shows the top of our base. The inner circle is to see if the magnet is still rotating, while the outer ring is to hold the drink. The marking in the top left of our lid is to make sure the lid is lined up with the base. The lid is only 8mm thick, thinning towards the center to allow for the magnetic field to easily find the magnet within the cup.

9 DESIGN DOCUMENTATION

9.1 FINAL DRAWINGS AND DOCUMENTATION

9.1.1 Engineering Drawings

See Appendix C for the individual CAD models.

9.1.2 Sourcing instructions

All components in this project were sourced with simplicity in mind. The housing for this design was made of 3D printed material, and is sized such that it can be printed on most 3D printers. The fan and magnet components were sourced from Amazon.com, making acquisition of these parts simple as well.

9.2 FINAL PRESENTATION

https://www.youtube.com/watch?v=-wXjHFxToW8

10 APPENDIX A - PARTS LIST

Part	Quantity	Acquired From
Stirrer Top	1	3D Printed at Washington University
Stirrer Base	1	3D Printed at Washington University
USB Computer Fan with switch, 80mm	1	Amazon
Hard Drive Magnet	1	Amazon
Magnet Stirrer Bar	1	Amazon

Table A-1: Parts List

11 APPENDIX B - BILL OF MATERIALS

Part	Quantity	Price	Acquired From
Stirrer Top	1	$0.00	3D Printed at Washington University
Stirrer Base	1	$0.00	3D Printed at Washington University
USB Computer Fan with switch, 60mm	1	$4.50	Amazon
Hard Drive Magnet	1	$0.71	Amazon
Magnet Stirrer Bar	1	$1.00	Amazon
Total Cost		$6.21	

Table B-1: Bill of Materials

12 APPENDIX C - COMPLETE LIST OF ENGINEERING DRAWINGS

Dimensions for the following drawings are in millimeters.

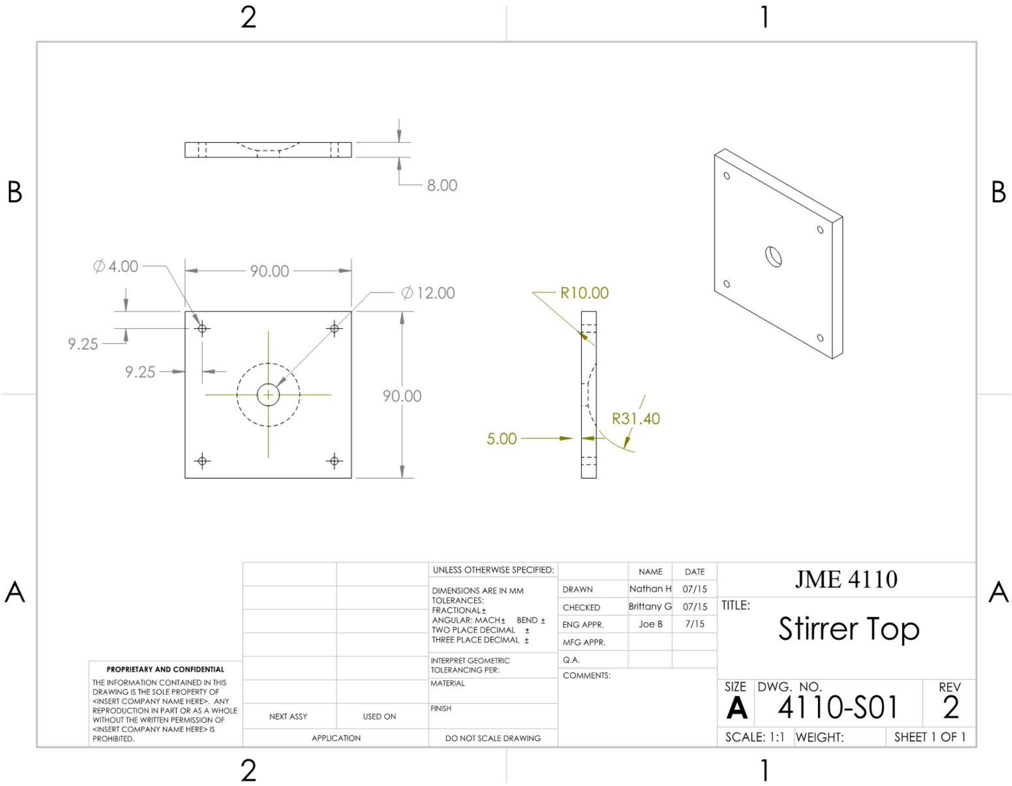


Figure C-1: Stirrer Top Drawing

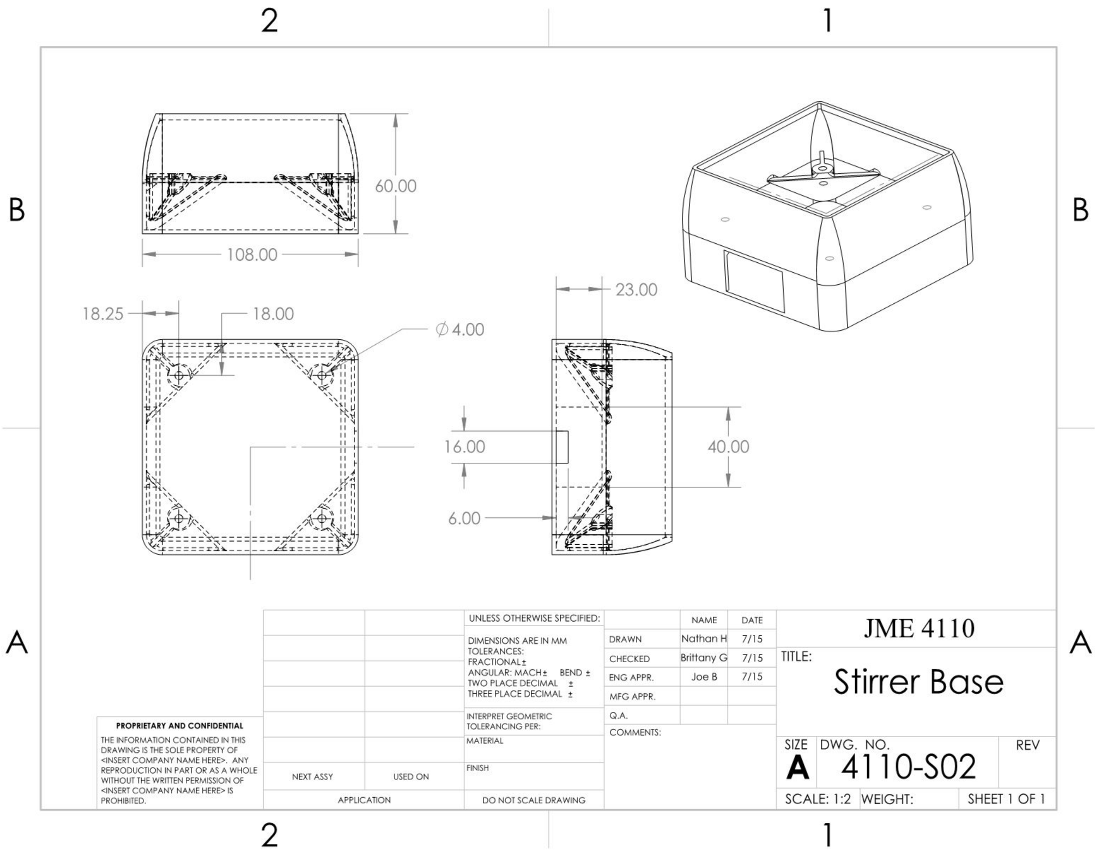


Figure C-2: Stirrer Base Drawing

13 ANNOTATED BIBLIOGRAPHY

1. Benson, L. and Reczek, K. (2016). *A Guide to United States Electrical and Electronic Equipment Compliance Requirements*.

   Used for codes and standards specifically for Electrical equipment.

2. Guide to Standards - Household Electrical Equipment. (n.d.). Sai Global.

   Used for Codes and Standards specifically for the guide.

3. Standard Specification for Additive Manufacturing File Format (AMF) Version 1.2. (n.d.). ASTM International.

   Used for codes and Standards specifically for 3D printing.

4. Standard Specification for Polytetrafluorethylene (PTFE) Resin Molded Sheet and Molded Basic Shapes. (n.d.). ASTM International.

   Used for codes and standards specifically for coating on the bar.

5. MC Wendl (2012) Theoretical Foundations of Conduction and Convection Heat Transfer, Wendl Foundation, DOI 10.13140/RG.2.1.1875.3120

   Used for Fluid Dynamics information.