MAE 2250 Spring 2014

Section 406

“The Hurricane” Drink Fountain Project Report

Team 6A:

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Section 1: Team Overview

Team Contact Information:

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Meeting Minutes:

Meeting 1, February 11th

At our first meeting, we exchanged contact info and available times, set up a lab notebook via Google Drive. We then began discussing our goals and deadlines for this project, particularly the first deadline, the PDR report and presentation, specifications for which we found on the MAE 2250 website. Ultimately, we came to the decision that we would stay on top of work, not letting it build up to the point that we felt overwhelmed by the work that was due.

Then we began to discuss project ideas we had brainstormed on our own. The ideas found in Section 2 of the design report, under "Considered Ideas" and listed with the person who thought it.

From here our group decided on our favorite ideas from each member: Lila's computer shelf, Sarah's coffee filter, Kyle's glass, and Trevor's glass filler.

Meeting 2, February 19th

After Kyle emailed the TAs and found out we had approval for all of our ideas (i.e. those that concerned alcohol,) we met after class to discuss next steps. Everyone agreed to pick our best ideas from the previous meeting and begin working on them (e.g. morphological charts and specifications.) Our next meeting, to choose idea, was decided to be Thursday, 2/20 at 4:30 pm in Duffield Atrium.

Meeting 3, February 20th

To start off, we identified that our presentation (PDR) and Initial Design Report Draft were due 2/24. Our biggest goal for the meeting - pick a product and timeline that gets us ready for Monday. We then overviewed the work people had done in between, listed below:

Sarah's French Press Filter:

Customer Interview:

-Don't like that French Press is all attached - hard to clean out grounds
-Problem: French Press lets grounds out, around outside of filter
-Grounds leak into coffee when using press as a coffeepot
-Hard to clean the bottom of press with oily grounds
-Coffee is "dirty" from grounds
-Grounds end up oily and caked at the bottom

Distilled Needs:

-Cleanable (would help if grounds didn't get packed at bottom too)
-Closeable (that is, grounds can be removed or sealed off at some point)
-Better seal around edges

Engineering Specifications:

-Must be watertight around edges during normal use
-Minimizes grounds re-entering solution when in use as a coffeepot
-Must not reduce volume of pot significantly
-Parts should be detachable for cleaning
-Must be able to adapt to current pots
-Cheap
-Designed elements should look as if they "fit in" with the presses they attach to.
-Foodsafe

Kyle's Bomb Drinking Glass:

Customer needs:

-Wheat grass tastes terrible. This way you can drink it and gain the benefits of it without that terrible lasting taste.

Competing products:

-There aren't really any competing products, nothing is like this. The only two other options are:

1) To just mix it in with your juice, but then you still taste it slightly the entire time.

2) To take the wheatgrass shot and then chase with juice, but you have to taste the wheatgrass for too long that way.

We also went over some of Trevor's work on his idea, but this is located in Section 3, conceptual design, as this is the idea we chose. We also discussed the challenge of using food safe material (only porcelain covering) for ideas - making slight redesigns.

Then, we needed to pick a final product. All group members agreed that the cup filler and drinking glass were our two best ideas. So, we made a pro/con chart to decide between these ideas, found in Section 2 under 'Product Choice' and ultimately chose the cup filling fountain. To end the meeting, we agreed to each design a specification and morphological chart, and to meet at 3pm on Sunday, February 23rd to put together a PDR and design report.

Meeting 4, February 23rd

When we met, we first went over everyone's work for the past week. Then we identified our goals for this meeting, to create a presentation document for our PDR and the first draft of our Design Report. We combined the things we had worked on individually to create a final version of the morphological chart, specification chart, and design decision matrix. Then we split ourselves in two to divide the rest of the work. Trevor and Lilia chose to work on creating slides for the PDR, while Sarah and Kyle decided to work on the design report. After working on these for a bit, everyone agreed to finish their assignments that evening and come back for a final review of each other's work in the afternoon the next day, 2:30 PM on February 24th.

Meeting 5, February 24th

In the afternoon before our presentation and report were due, we went over the two team's work, and split up presentation duties for that night's lab.

Then, in lab, we found out we had some issues with the manufacturability of our product. The maximum part length was 6". To combat this, we decided to scale our design down, no longer catering to all different sizes of glasses, and simply focusing on pouring into small glasses. This also meant we could get rid of the large funnel we had in our initial concept, replacing it with one that was intended only to be poured into.

Meeting 6, February 25th

Our goal for this meeting was to identify all the geometries of our product. First, we created a list of each measurement we would have to identify. These can all be found in Section 4, Geometries. After doing this, we agreed to split up the major tasks for the second week. Trevor would be responsible for CADing the model, Sarah and Lilia for doing analyses, and Kyle for investigating intellectual property. We then agreed to meet back on March 2nd to compile these data into the report and presentation for lab week two.

Meeting 7, March 2nd

This meeting was perhaps our most challenging yet. While we were really happy with the way the CAD of the device came out, we realized we had a huge issue with material cost. Our device's dimensions, while optimized for ceramic, would cost over 300 dollars. To bring out product into budget, we would need to cut the amount of material by 73%. Our group decided we would talk to Professor Lipson and our TAs about whether this project was still feasible, or whether we needed to begin developing another idea. Still, we split up CDR responsibilities, as we plan to present tomorrow what we worked on over the past two weeks. Sarah will continue the design report, and Kyle, Lilia, and Trevor, will put together the presentation.

Meeting 8, March 4th

We all came to this meeting thinking of different options. Our general plan moving forwards was to move away from 3D printing, and towards standard parts purchased off McMaster Carr. The biggest problem we had with our first design was that we were, in short, reinventing the wheel. Printing things like tubes and stands is extraordinarily expensive, but it doesn't provide a significant advantage over similar parts at mass produced prices. The first decision we were able to make was purchasing plastic tubing. The tubing only costs around a dollar a foot, so it was an incredibly economic decision. The largest problem with the tubing is its extremely low coefficient of thermal conductivity. The ice chamber in the previous design only cooled liquid on the order of one degree Fahrenheit, and with the tubing, it would cool even less, thus, we got rid of this portion of the design. Next, we decided to make the base out of a laser cut platform and a rod that screws into it. Finally, for the main design of the pourer, we chose to make a sort of plastic frame that consists of a top funnel, tube holding rings, and stand attachment. A full CADing of the design is found in Section 2 of this report. We then split up remaining responsibilities for the week. Kyle would re-examine our morphological and decision charts, Lilia would re-work our engineering analyses, Sarah would order parts, and Sarah and Trevor would CAD the design.

Meeting 9, March 7th

At this meeting, we all caught up with the current design. We showed the CAD model, defined exact geometries, ordered parts (and specified why they were needed.) This allowed everyone to finish their week tasks by Sunday/Monday in time for the third week report. It also would get everyone on track to assemble our design during the next week. Sarah was responsible for finishing and submitting the CAD models to be printed, ordering parts, and putting together the design report: designing tests, documenting iteration two, analyses, cost report, geometries, renderrings, and assembly.

Meeting 10, March 9th

In lab tonight, our group was told that our prototype (Iteration 2) could not be printed in its current form. Though it met all requirements listed for 3D printing, it's geometric complexity would take many hours to print, and the lab was not willing to do this for us. While first we were frustrated, we figured to make a new prototype design - one that could be printed in multiple parts and then glued together. Still, we plan to keep Iteration 2 as our final design - we assume Shapeways will print it. If they do not, we can always refer to our prototype design. Unfortunately, this means we are printing the skeleton of our design in multiple parts, which we were trying to avoid. Trevor and Sarah set off redesigning the prototype, as that needed to be printed as soon as possible to allow for assembly and testing time. Meanwhile, Lilia and Kyle began designing marketing materials, that is, user documents (the stuff you would find in the box with our product) and a website aimed to sell our design. Trevor and Sarah, after talking to the TAs, decided that the easiest way to split our design up was to make six parts: the funnel, bottom piece, and four arms. The funnel and bottom piece could have small "sleeves" facing outwards, in which the arms of the design could nest. Then we plan to glue these pieces together, using silicone sealant. While not optimal, it should provide a nice looking and functional proof of concept, though the final product should be a bit nicer.

Meeting 11, March 10th

Today, Sarah and Trevor met to finish the prototype CAD. We worked in the Upson basement computer lab, and successfully finished our design. Using an assembly, we made sure that the skeleton arms fit inside the nesting sleeves, in terms of size, shape, and angle. Finally, Sarah submitted a zip of the CAD files to the Cornell Box to be 3D printed. Though there was an initial problem with the formatting of the design, Sarah figured it out. After this, we simply needed to wait for our parts to come in (those from the 3D printer and from McMaster Carr) to assemble and test our design.

Meeting 12, March 14th

Today, we all met to look at the prototype. Sarah had redesigned and reprinted one part and glued the assembly together, as well as adding the tubes to the frame. We were very pleased with the way the project looked at this point in time, not homemade at all. Overall, the reason for this meeting was to come on with a marketing plan and a general plan for capping off the project. Sarah agreed to finish assembling the prototype, take pictures, videos, and carry out tests and evaluation. She would also forward these materials to the rest of the team. Trevor would take user testimonials, as well as create materials for the website. Lilia would head up the bulk of the website design, including the marketing materials from Sarah. Finally, Kyle would create the user manual for the product, and take results from a consumer survey that details likelihood of purchase.

Meeting 13, March 17th

At lab tonight, we identified our responsibilities for the final week of the project. We realized that the main things we had to do were put together a great FDR, and compile our weekly report into the final design report. Trevor, Kyle, and Lilia agreed to work on the FDR, making the slides that detailed our design progress from the first week and onwards. Sarah, meanwhile, would finish the design report, as she had been compiling it for the project thus far. Trevor also agreed to make a CAD assembly which includes the purchased parts of our product. We agreed to meet on Thursday afternoon, with everyone having completed the slides of the FDR, so we could see if there were any gaps in needed information that needed to be taken care of.

Meeting 14, March 20th

Today we met to quickly go over the slides Trevor, Kyle, and Lilia had compiled. They documented the design process from the beginning, but really focused on the product we had produced. We split up slide responsibilities to present for the FDR presentation. Kyle will start off, speaking a little about our general process, and project schedule. Lilia will then talk about how we came to decisions about our individual design - early concepts, decision matrices, and morphological charts. Then Sarah will speak about our current design, how we reiterated pieces, manufactured, and tested the drink fountain. Finally, Trevor will finish off, discussing costs, marketing, and our product website. We decided to meet Friday afternoon so that everyone could try their speaking piece, and make sure that everyone's pieces meshed well into a good presentation of our process.

Meeting 15, March 24th

Because Kyle realized that he couldn't come to a meeting on Friday, we decided to review our FDR on Monday. We got together in Duffield, and first just made sure we were ready to be done with this project! Thankfully, we were. Then, we set up a compute with the FDR slides, and spoke our parts. Our presentation time was 14.5 minutes, and we were happy with the material presented. That said, our project was complete, and we were proud to hand in our materials for the Design Make Sell Project.

Presentation Materials:

PDR

Drink Fountain PDR

Team 6A: Trevor Alexander, Kyle Coble
Hedan Lillia Bai, Sarah Angle
February 24th, 2014

Kiddush drink fountain

Hey, I know this looks beautiful.
But $120 for one piece?! Come on!

Market

- College Students
    - Easier to pour drinks for groups
    - Fun
    - Affordable version of Kiddush fountain
- Bars
    - Looks great
    - Has functionality
- Home-owners
    - oRom-piece
    - Guests

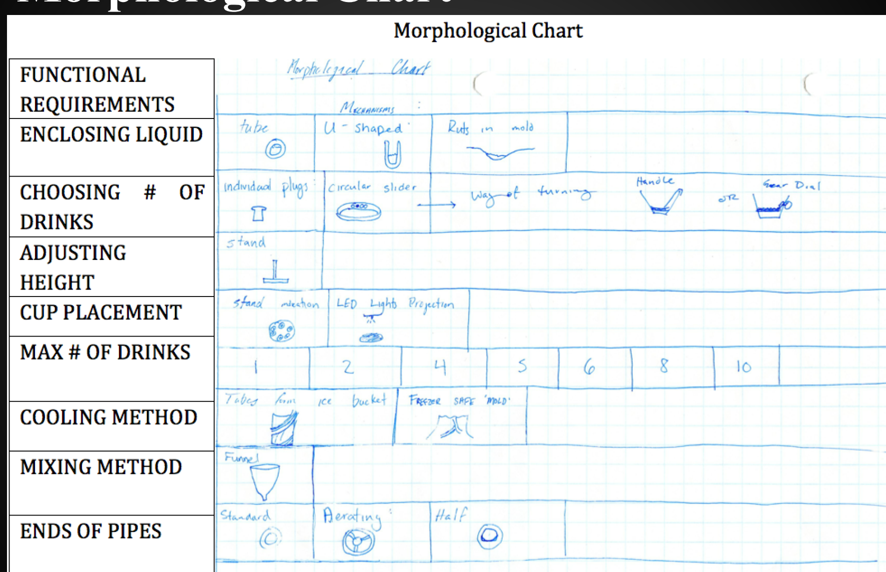
Customer Needs

1. Foodsafe
2. Pours evenly
3. Pours cold
4. Easily cleaned
5. Safe/strong against falls
6. Mixes evenly
7. Makes correct number of drinks
8. Compact
9. Pours neatly
10. Supports many types of drinks
11. Looks good

Specification Chart

#	# of need	Specification	Unit	Ideal Value	Acceptable Value
1	1	Foodsafe	Boolean	TRUE	TRUE
2	9	Height(s) to table top	Range-inches	1 - 10	5 - 7
3	7	Number of paths opened	Integer list	1, 2, ..., n	1, n
4	2	Volume change for different paths	% difference	0	< 10
5	3	Keeps drink at same temp (or colder) as they were poured	degree Far. difference	< 0	< 5
6	5	Withstands height of fall without damage	ft	> 6	> 2
7	4	% of dirtied area accessible to clean	%	100	any
8	8	Effective volume	ft^3	< 2	< 4
9	6	Volume of mixing chamber	oz.	16 per path	4 per path
10	9	Volume lost to spillage	% total vol.	0	< 10
11	10	Drinks supported	list	> 5 types	1 type

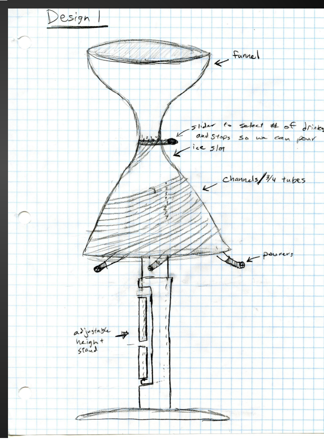
Morphological Chart



Selected Concepts

Design 1

-funnel allows mixing and build up before flow
-slider controls number of pipes that are open
-cone has opening for ice and spout for melted water
-stand has adjustable heights for different sized cups



Selected Concepts

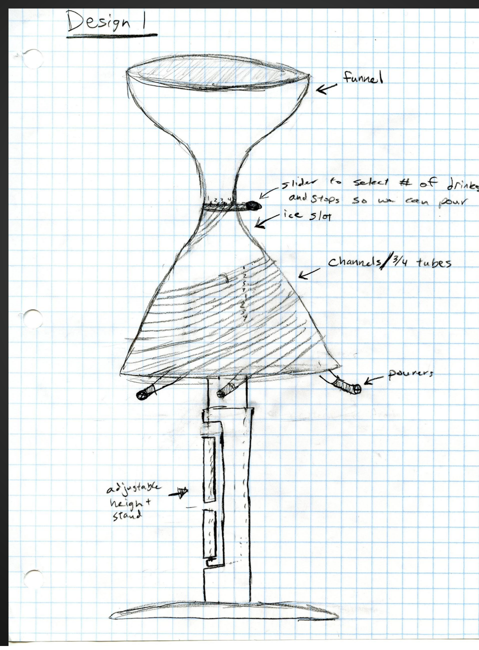
Design 3

-Simple holder for cups
-Small, short paths for liquids to follow
-Found at GreenField Judica

Pew Decision Matrix

criteria 1-10	Importance %	Design1	Design2	Design3
adjustibility	10	10	5	0
complexity	25	6	2	8
stability	10	4	4	6
ease to clean	5	5	5	6
cooling ability	10	10	5	0
size	5	8	8	8
looks	20	9	9	5
mixibility	5	10	0	8
cost	10	6	4	9
total score		6.85	4.75	4.7

Final Choice: Design 1



Project Schedule

Milestones

- ❏ Complete preliminary detailed design 02/25
- ❏ Finish full product analysis 02/28
- ❏ Finalized CAD model, production drawings and assembly documentation 03/02
- ❏ Prototype fabrication completed 03/05
- ❏ Performance test evaluated 03/08
- ❏ Usability evaluated 03/09
- ❏ User manual and instructions formulated 03/12
- ❏ Marketing material, advertising material and distribution channel (website) finalized 03/16

Project Schedule

Responsibilities

Week 2

- ❖ Product mechanical analysis: Lillia and Sarah
- ❖ CAD model, production drawings and assembly documentation: Trevor and Kyle

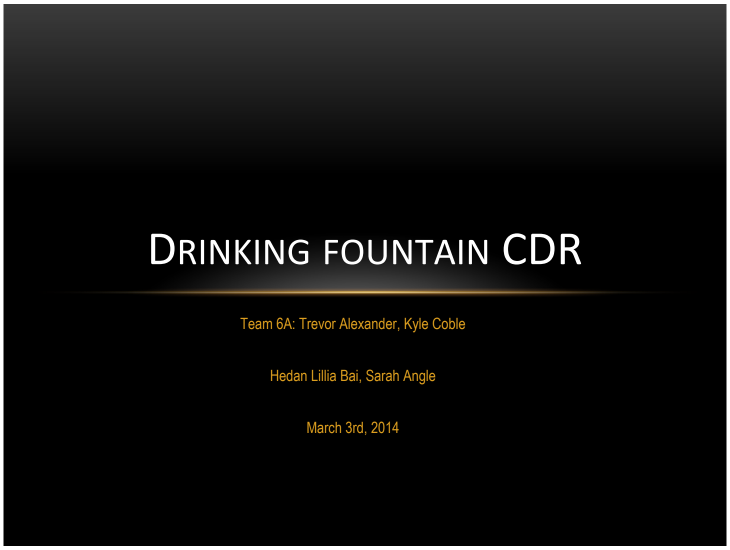
Week 3

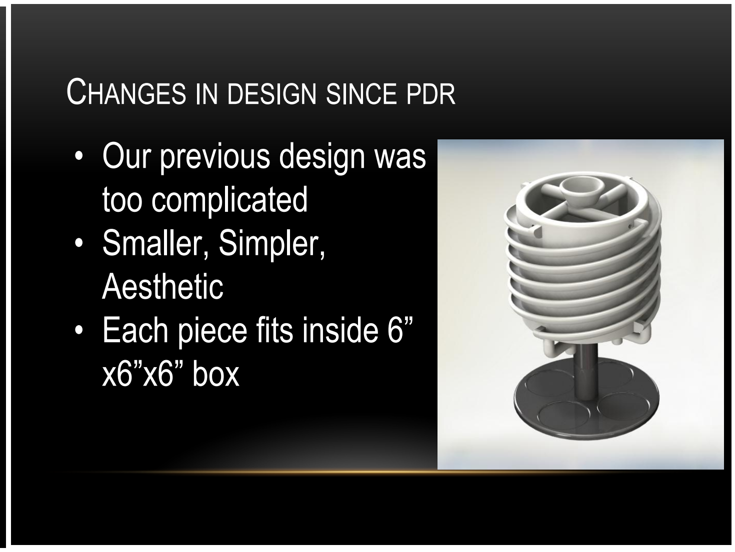
- ❖ Prototype fabrication
- ❖ Performance test and usability analysis

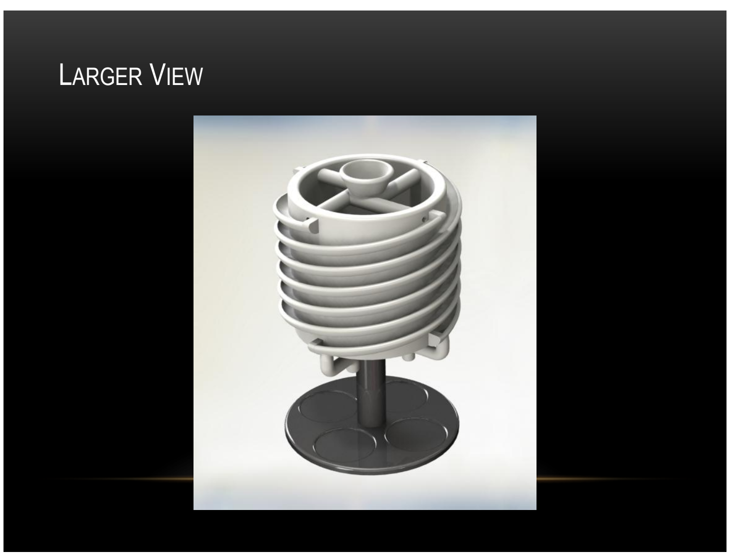
Week 4

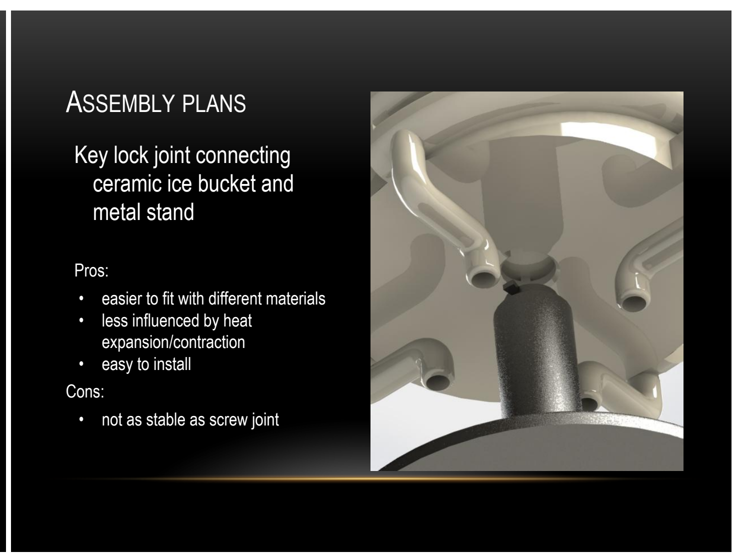
- ❖ User manual and instructions
- ❖ Marketing, advertising and website

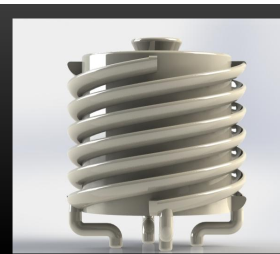
CDR


DRINKING FOUNTAIN CDR
Team 6A: Trevor Alexander, Kyle Coble
Hedan Lillia Bai, Sarah Angle
March 3rd, 2014


CHANGES IN DESIGN SINCE PDR
• Our previous design was too complicated
• Smaller, Simpler, Aesthetic
• Each piece fits inside 6" x6"x6" box


LARGER VIEW


ASSEMBLY PLANS
Key lock joint connecting ceramic ice bucket and metal stand
Pros:
• easier to fit with different materials
• less influenced by heat expansion/contraction
• easy to install
Cons:
• not as stable as screw joint



HAND CALCULATION CONCLUSION

1. Fragility Analysis

   A. Funnel and bucket connection

   》Force required to break at connection: 5.32e9N sufficient to survive a fall

   》Bending stress (1146 psi) and compressive stress (0.08 psi) are well below flexural strength (15e3 psi) and compressive strength (120e3 psi)

   B. Groove arm

   》Force required to break the arm: 1.31e11 N sufficient to survive a fall

HAND CALCULATION CONCLUSION

2. Flow rate analysis

   》Max Fluid Flow Through Funnel: 0.7 m/s

   》Max Fluid Flow Through Tube: 0.1 m/s

   》Time to flow down the tube: 6 s

   》Total time to fill 4 1.5oz glasses: 18 s

Cost analysis

IceBucket -
Volume - 50.13 cubic inches
Material - Food-Safe Ceramic
Price - $.35/cm^3 + $6 = $293.52 (Shapeways)

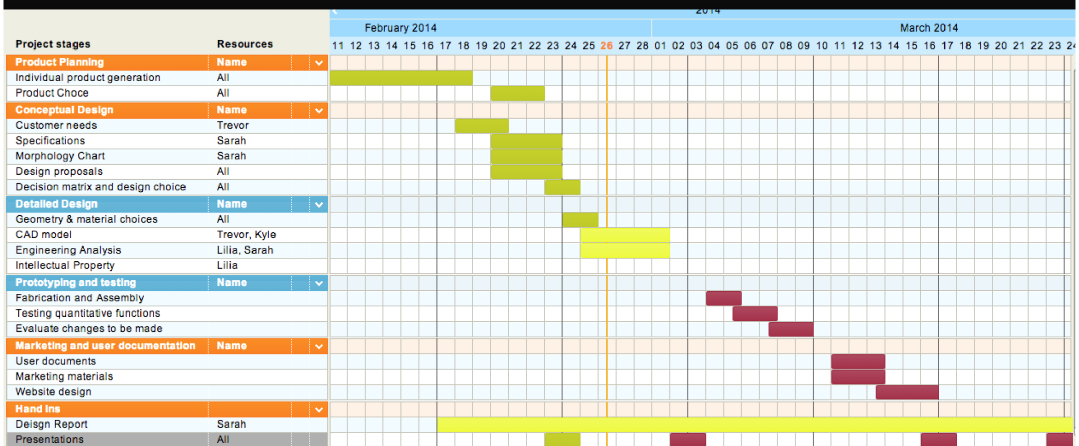
Stand-
Volume - 8.32 cubic inches
Material - Steel
Price - $8/cm^3 + $6 = $1096.72 (Shapeways)
TOTAL- IceBucket + Stand = $1390.24 = 13.9*max_price

Possible Solutions

- Switch to plastic
  - Thinner, Cheaper, Food-safe Spray
- Four point Base

  Still Too Expensive
- McMaster Base
- PVC tubes

GANTT CHART



Bottlenecks

This week -> Need to redesign product AND
Begin prototyping and ordering parts

Next week -> If we only just get parts in this
weekend, testing and reiteration

Cost -> How far apart are prototyping and final cost?

Pros and Cons of Current Design

Pros:

- Fun
- Aesthetic
- Four Tracks
- Stable
- Key Lock Joint
- Food Safe Material

Cons:

- Cost
- Volume of Material

FDR


THE HURRICANE
Group 6A:
Trevor Alexander, Kyle Coble, Hedan Lillia Bai, Sarah Angle

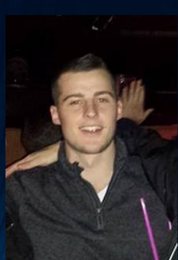

Share your drink,
share your party!

Final Design Presentation Outline

- Personnel
- Schedule
- Background
- Customer specifications
- Project overview
- Design features
- Manufacturing
- Engineering analysis
- Testing
- Cost analysis
- Website
- Product use and evaluation
- Conclusion

Personnel

Trevor Alexander



Mechanical Engineering
Cornell University '16

Sarah Angle

Mechanical Engineering
Cornell University '16

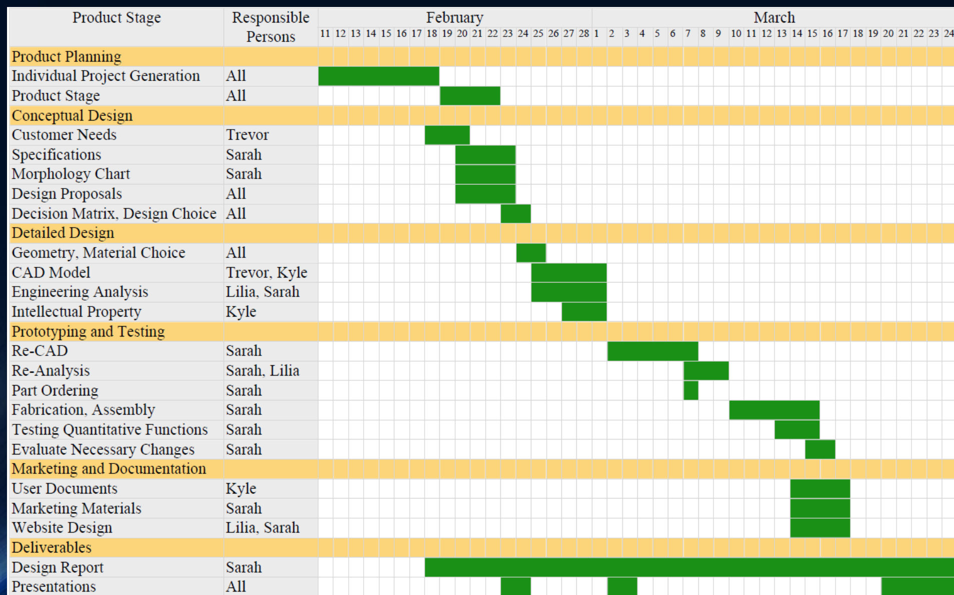
Hedan Lillia Bai

Mechanical Engineering
ORIE
Cornell University '16

Kyle Coble

Mechanical Engineering
Cornell University '16

Schedule



Why YOU need The Hurricane

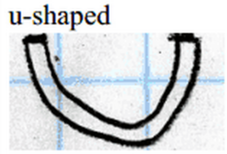
- Pour Four Drinks at Once
- Party Fixture
- Fun to Use
- Room Centerpiece

CUSTOMER SPECIFICATION CHART

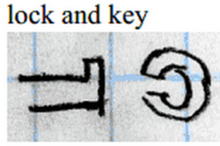
#	# of need	Specification	Unit	Ideal Value	Acceptable Value
1	1	Foodsafe	Boolean	TRUE	TRUE
2	9	Height(s) to table top	Range-inches	1 - 10	5 - 7
3	7	Number of paths opened	Integer list	1, 2, ..., n	1, n
4	2	Volume change for different paths	% difference	0	< 10
5	3	Keeps drink at same temp (or colder) as they were poured	degree Far. difference	< 0	< 5
6	5	Withstands height of fall without damage	ft	> 6	> 2
7	4	% of dirtied area accessible to clean	%	100	any
8	8	Effective volume	ft^3	< 2	< 4
9	6	Volume of mixing chamber	oz.	16 per path	4 per path
10	9	Volume lost to spillage	% total vol.	0	< 10
11	10	Drinks supported	list	> 5 types	1 type

Project Overview
(morph chart,decision matrix, previous design iterations)

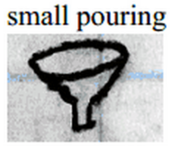
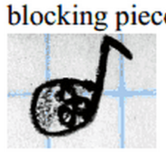
Morphological Chart

Liquid Transportation	full tube 	cantilevered channel 	u-shaped 	
Drink Cooling	steel ice bucket 	3D printed ceramic (See Iteration 1 for better picture)	no cooling	

Project Overview
--Morphological Chart

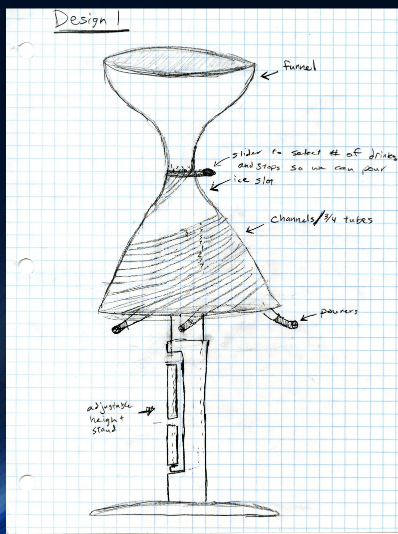
Base Shape	square 	circle 	cross-shaped 	
Stand shape	hollow tube 	solid tube 	hex tube 	purchased adjustable stand
Stand Connection	screw 	lock and key 	sit-in (See Iteration 2 for better picture)	

Project Overview
--Morphological Chart

Funnel	large mixing 	small pouring 		
Selecting No. of Drinks	rubber plugs 	blocking piece inside 	no blocking	

Project Overview

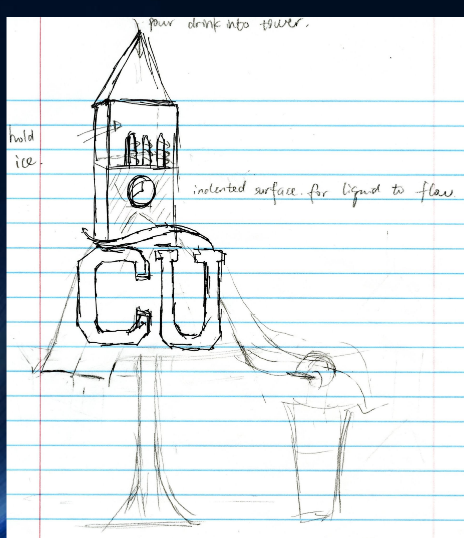
Design 1



- Funnel allows mixing
- Ice bucket enables cooling
- Adjustable number of cups to fill
- Adjustable stand height

Project Overview

Design 2



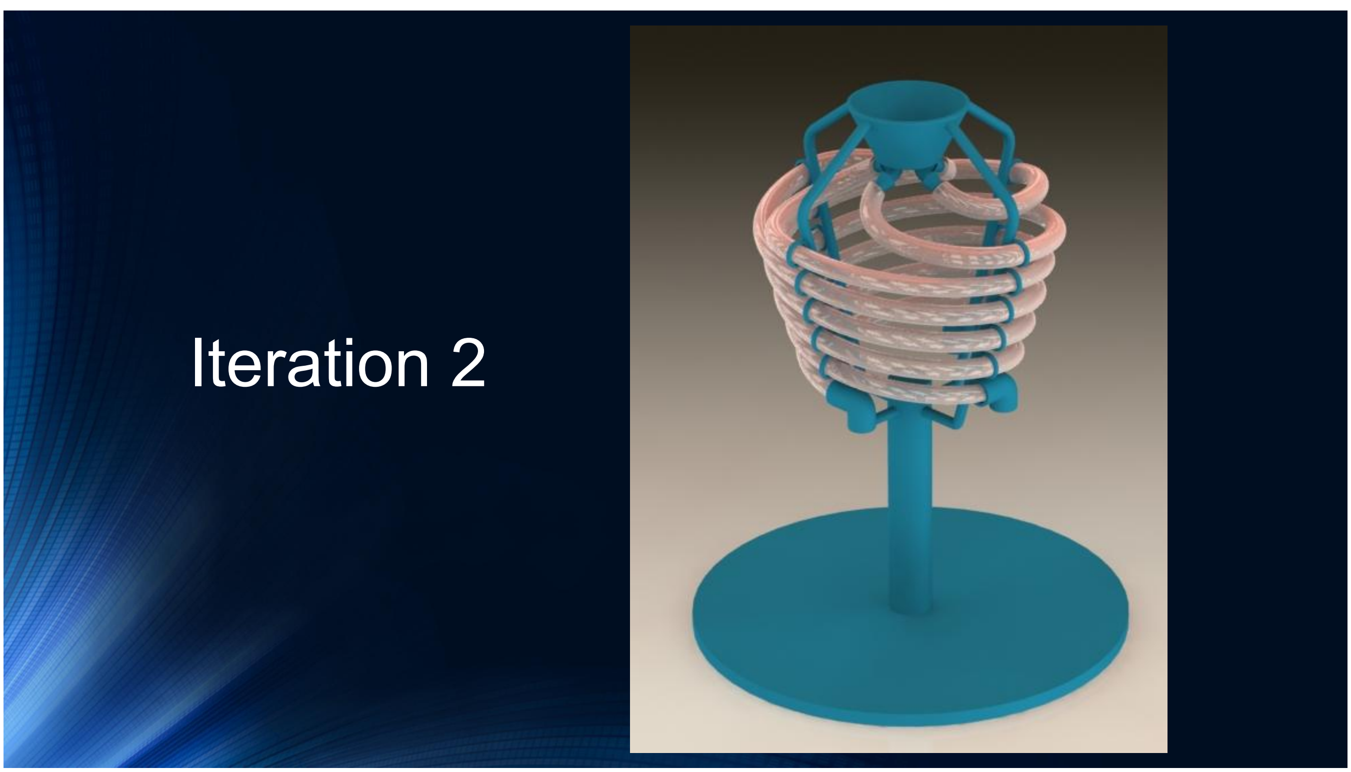
- Creative mold
- CU theme
- Ice bucket enables cooling
- Aesthetic value

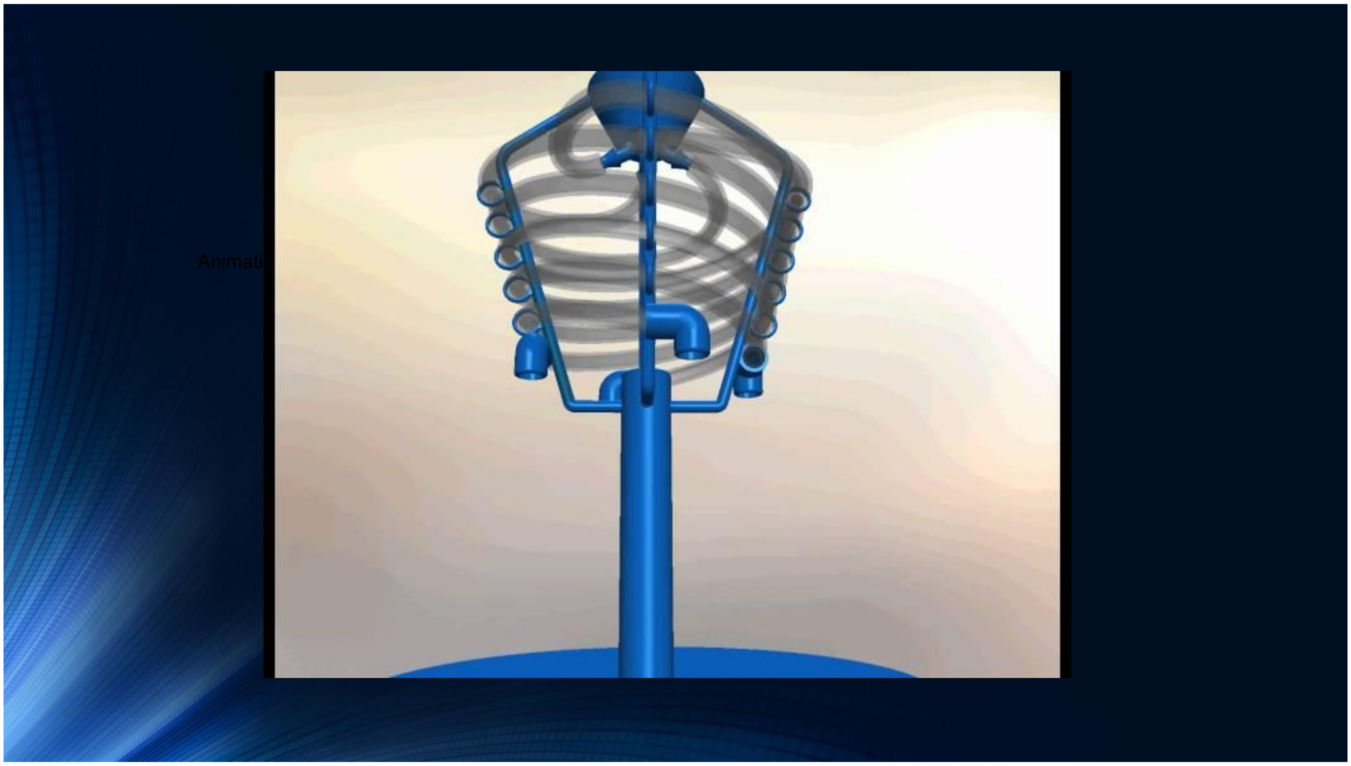
PUGH DECISION MATRIX

Criteria	Importance (%)	Design 1	Design 2	Design 3
Adjustability	10	10	5	0
Complexity	25	6	2	8
Stability	10	4	4	6
Ease to clean	5	5	5	6
Cooling ability	10	10	5	0
Size	5	8	8	8
Appearance	20	9	9	5
Mixability	5	10	0	8
Cost	10	6	4	9
Total Score		6.85	4.75	4.70

Iteration 1


PROS
Cools Liquid
Sturdy
Aesthetically pleasing
Easy to use
CONS
Expensive to produce
Fragile
Heavy
Abandoned due to high cost


Iteration 2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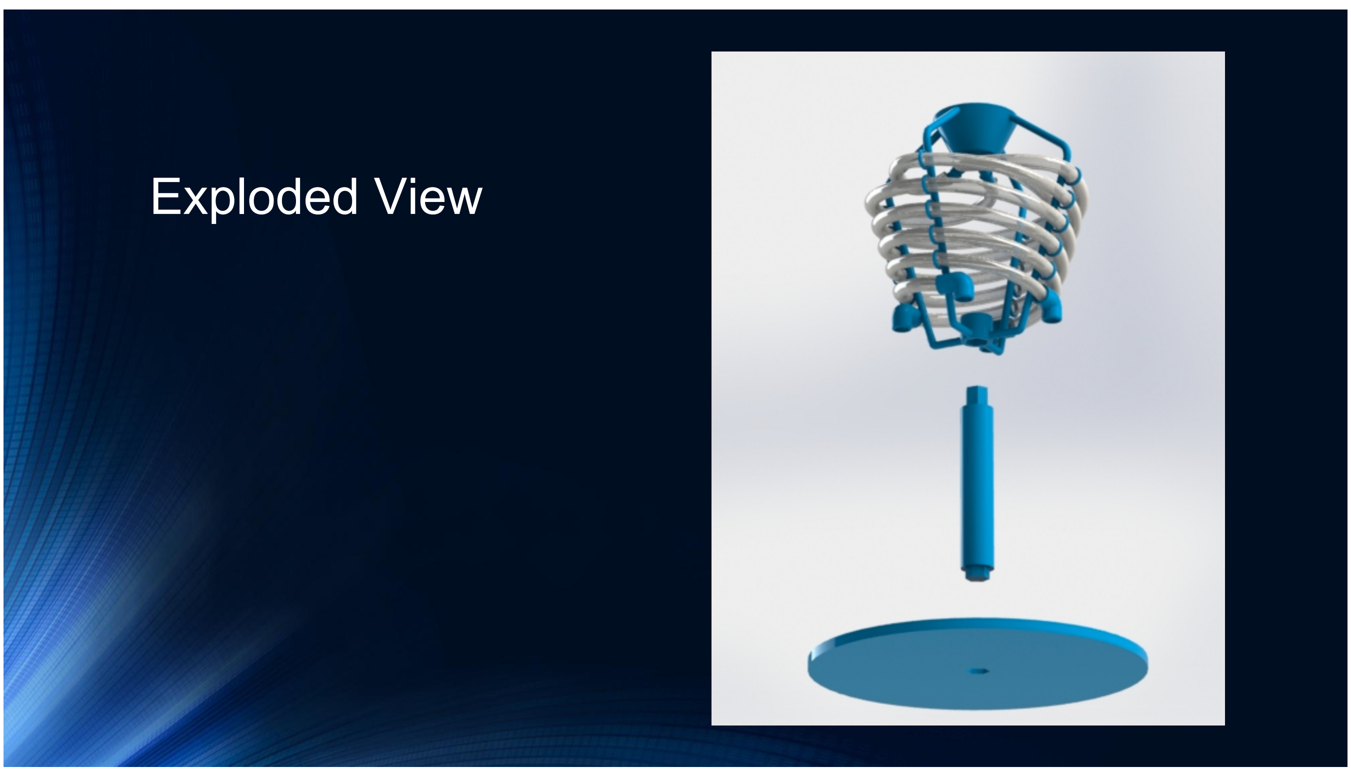
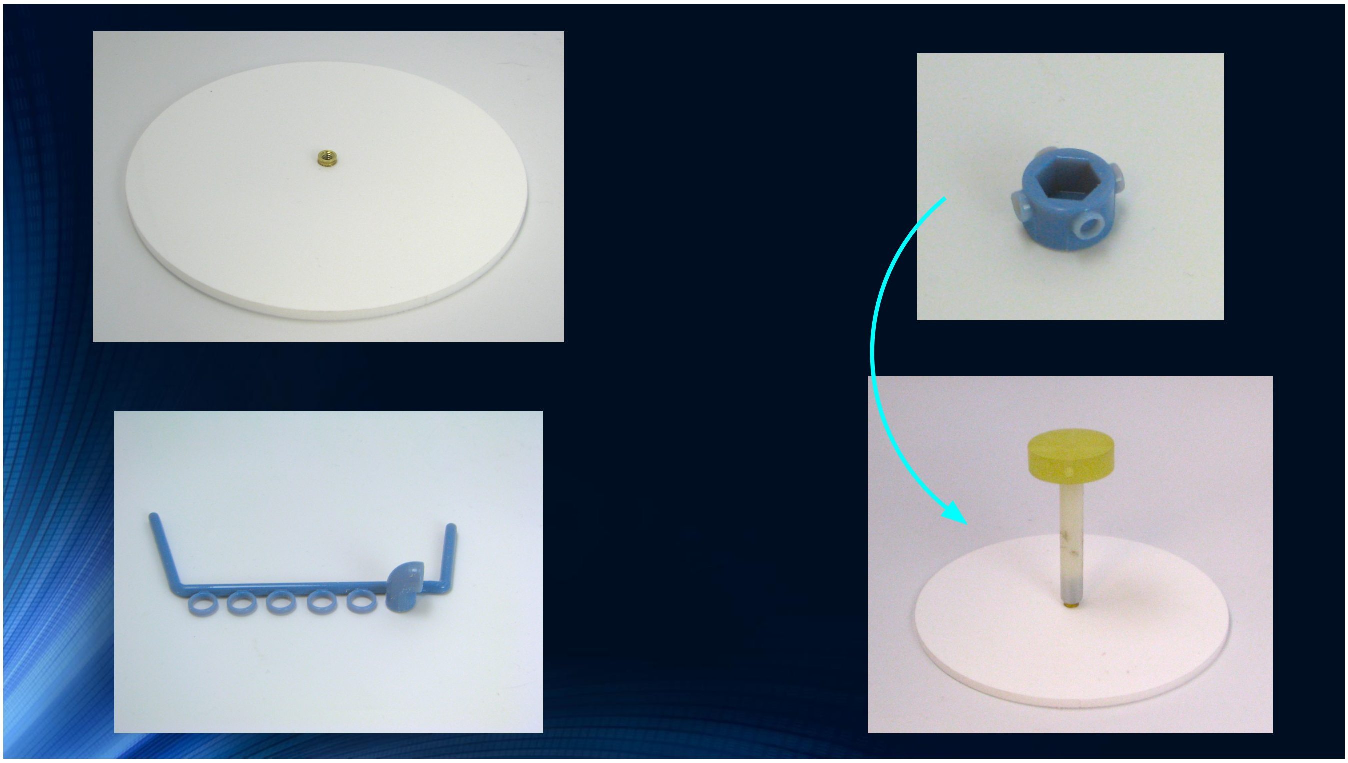
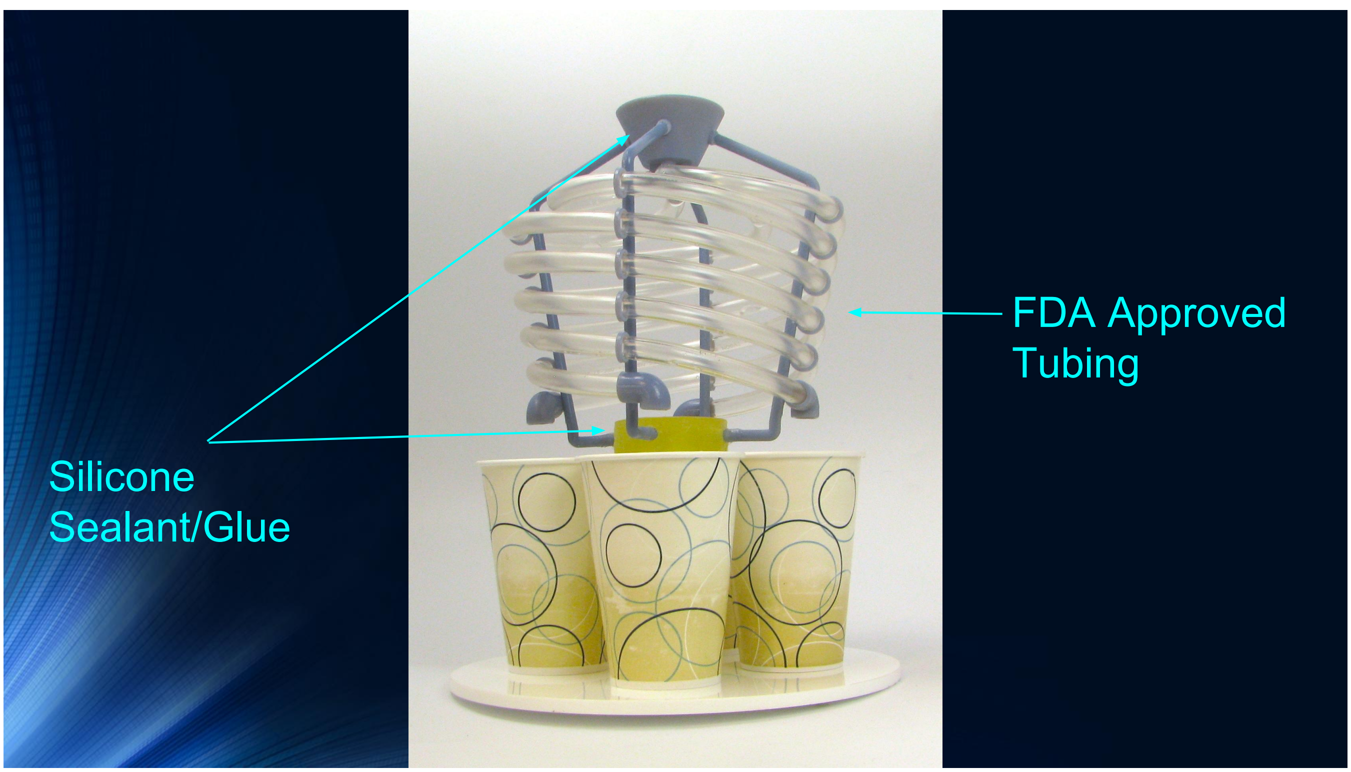

Exploded View




FDA Approved
Tubing
Silicone
Sealant/Glue

Engineering Analysis

- Moment to begin knocking pourer over

  Force required to overcome moment of weight: 0.47N

  Slightly more stable than average coffee mug

- Strength of funnel connection

  Allowable stress for plastic: 40 MPa

  Allowable force on all four rods: 31.5 N; total weight supported at funnel: 0.4 N

  Factor of safety over fifty

Engineering Analysis

- Maximum flow rate through funnel and tube

  Maximum flow rate through tube: 0.736 m/s

  Flow rate through tube: terminal velocity 0.1 m/s

  Time to fill four shot glasses: 5 s

- Bending and shear force on tube holders

  Allowable bending force: 242 N

  Allowable shear force: 726 N

  Tube holders are unlikely to be broken under bending or shear force

Testing

Pouring Uniformity
- 3mL or 7.5% max difference

Splashback
- None

Rinse to Clean test

Shipping Volume
- 8x8x7.25” box if detached / 8x8x10.5” if assembled

Clearance Height
- 4.25”

Knock-over test

Cost Analysis

Item	Source	Price/Unit	Unit	Cost
Frame	Shapeways	\$2.25 + \$1.50/cm^3	39.17 cm^3	\$61.00
Laser Cut Base	Cornell Lab	Complex, calculated per piece	1 piece	\$7.97
Tubing	McMaster Carr	\$1.39 / ft	6.5 ft	\$9.04
Silicone Sealant	McMaster Carr	\$3.95 / tube	10% tube	\$0.40
Thermoplastic Insert	McMaster Carr	\$9.15/ 25 pcs.	1 unit	\$0.37
Steel Stud	McMaster Carr	\$1.07 / unit	1 unit	\$1.07
Nylon Standoff	McMaster Carr	\$8.15 / unit	1 unit	\$8.15

- **Total cost \$88**

Website → The Hurricane

Product Use and Evaluation

Section 2: Product Planning

Project Purpose:

The goal of this project is to design a consumer destined product to be created with 3D printed, laser cut, and standard purchased parts. In this project, we should experience every part of the design process, from initial conception to fabrication to analysis to marketing. Each of these stages should be performed in such a way that it helps make the best product given our tight restraints of only five weeks time and ninety-nine dollars budget.

Products Considered:

Each person's individual product concepts are listed below their name, along with pros and cons that were generated at the first group meeting.

Lilia:

A computer shelf for when you lay in bed for watching movies and doing homework.
-Pros: Practical, solves common problem and is well suited for the fabrication methods available (3D printing and laser cutting)
-Cons: All angles of visibility and stability would be hard to design, there are similar products like lap desks

Hair removal device that uses sticky material to pick up mess
-Pros: Does gross (cleanup) work for you
-Cons: Pretty similar to a lint roller, may not have much mechanical design, sticky material would pick up carpet as well

Nightlight set that includes a lamp and humidifier
-Pros: Could be designed beautifully and artistically, serves many uses
-Cons: Group does not have expertise in humidifier design/electrical design, doesn't necessarily fill needs of project

Sarah:

French press filter with a lock down piece to stop grinds from re-interring coffee.
-Pros: Good scale and material choice for product, good solution for coffee drinkers
-Cons: Must fit on/into other products, niche market

Phone case for construction/climbing/sports uses that can lock onto a belt and come off with a retractable leash

-Pros: Fits need that isn't filled, fairly simple design

-Cons: It has to work (can't ruin phones), may be hard to design a retracting belt

Kyle:

Bomb drinking glass, angled in a way that allows two drinks to be poured in easily

-Pros: Very marketable, simple design

-Cons: a bit tacky, not the most innovative product

Jar scooper/spatula that allows user to get all of the product

-Pros: small and simple design, cheap

-Cons : very unnecessary

Trevor:

Can opener that works with punch action

-Pros: cans are already uniform, safe, more efficient than current products

-Cons: more complex, lots of mechanical pieces, can only work for one size can

Cool, fun glass filler

-Pros: fun, easier, novelty, allows lots of room for artistic design

-Cons: very unnecessary

Product Choice:

When we first began discussing ideas, our group quickly identified our favorite ideas, that is, Sarah's coffee press filter, Trevor's drink dispenser, Lilia's laptop holder, and Kyle's drinking glass. However, when it came time to pick our final favorites, we split evenly between the drinking glass and drink pouring fountain. To pick between these two ideas, we created a pro/con list, shown below:

Glass Pro	Glass Con	Pourer Pro	Pourer Con
doesn't suffer as much in ceramic	takes away some of the drink experience	more fun looking	more difficult to design and make
cheaper		more value added	costs more
easier to make		more creative	
		more analysis	
		marketable	

So, in the end, we chose to make the drink pourer, because it allows us to be more design focused, more creative, and more analytic. We also did a bit of research and found that our idea had similarities to a traditional Kiddish wine pourer. This gave us a decent resource for looking at devices that did similar things, though our product would be much cheaper, and aimed at a difference customer.

Section 3: Conceptual Design

Customer Interviews:

For our product that pours drinks in a fun and creative way, we imagine our customers in primarily two ways: young adults at parties or gatherings who want to mix and pour drinks for friends, and bars who want an artistic and functional piece to display around their venue. Trevor conducted two interviews with other Cornell students who may be interested in buying a piece like the one we are designing. When asked what they would like from a multiple drink pourer, here are some responses they gave:

"You have to have the same amount in each cup."
"The drinks have to be cold."
"It should look cool."
"I don't want it to get messy."
"Don't want it to break during a party."
"All the mixed drinks should taste the same."
"It has to make enough."
"It could make it taste different, like adding lemon."
"Has to be easy to carry up and down stairs."
"Don't want drinks to splash all over the place."
"Should pour lots of types of drinks."
"Maybe it could aerate wine too."

Customer Needs:

Using the interview results listed above, we compiled an itemized list of needs that we aggregated from the customer interviews as mentioned above.

1. Food safe
2. Pours evenly
3. Pours Coldly
4. Easily Cleaned
5. Safe/Strong Against Falls
6. Mixes Evenly
7. Makes Correct Number of Drinks
8. Compact
9. Pours Neatly
10. Supports Many Types of Drinks

Specifications:

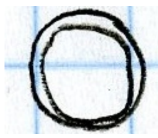
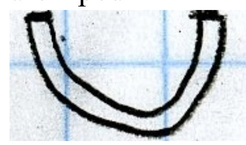
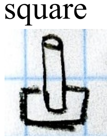
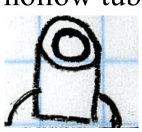
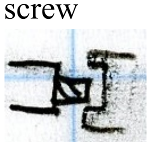
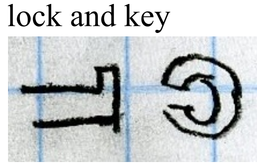
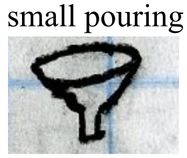
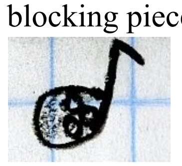
The table below turns the above customer needs into a specification matrix. It references the numbers of the needs, and assigns units and values to corresponding specifications.

#	# of need	Specification	Unit	Ideal Value	Acceptable Value
1	1	Foodsafe	Boolean	TRUE	TRUE
2	9	Height(s) to table top	Range-inches	1 - 10	5 - 7
3	7	Number of paths opened	Integer list	1, 2, ..., n	1, n
4	2	Volume change for different paths	% difference	0	< 10
5	3	Keeps drink at same temp (or colder) as they were poured	degree Far. difference	< 0	< 5
6	5	Withstands height of fall without damage	ft	> 6	> 2
7	4	% of dirtied area accessible to clean	%	100	any
8	8	Effective volume	ft^3	< 2	< 4
9	6	Volume of mixing chamber	oz.	16 per path	4 per path
10	9	Volume lost to spillage	% total vol.	0	< 10
11	10	Drinks supported	list	> 5 types	1 type

Concept Generalization:

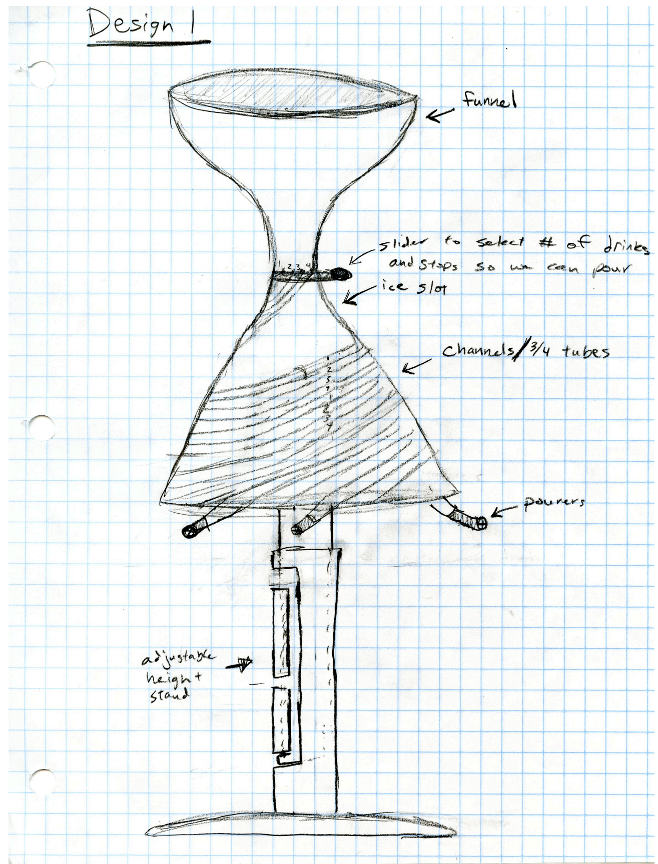
One way we gathered designs for our concept was looking at existing designs for Kiddish wine pourers. These devices are expensive and ornate, but perform simply the function we set for our product. We also brainstormed and designed the following morphological chart:

Morphological Chart

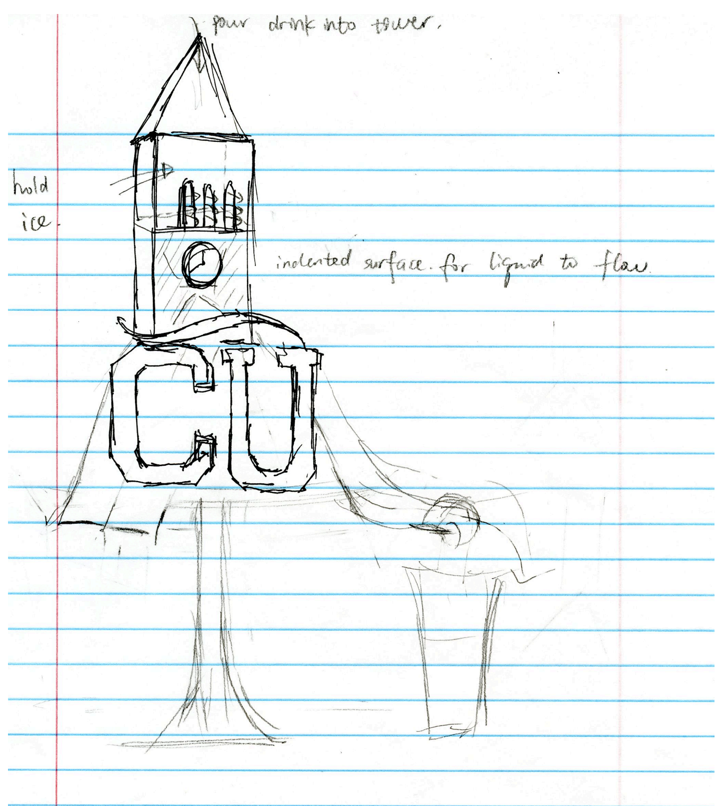
Liquid Transportation	full tube 	cantilevered channel 	u-shaped 	
Drink Cooling	steel ice bucket 	3D printed ceramic (See Iteration 1 for better picture)	no cooling	
Base Shape	square 	circle 	cross-shaped 	
Stand shape	hollow tube 	solid tube 	hex tube 	purchased adjustable stand
Stand Connection	screw 	lock and key 	sit-in (See Iteration 2 for better picture)	
Funnel	large mixing 	small pouring 		
Selecting No. of Drinks	rubber plugs 	blocking piece inside 	no blocking	

Concept Selection:

To turn the individual ideas from our morphological chart, we combined preferred combinations into two designs. Design 1 was formed by using tubes as the main structure of the pourer, while design 2 is structured more from a mold. They are pictured below.



Design 1:
- -funnel allows mixing and build up before flow
- -slider controls number of pipes that are open
- -cone has opening for ice and spout for melted water
- -stand has adjustable heights for different sized cups



Design 2:
- -Creative mold (for example, a CU themed one)
- -Area towards top to hold ice
- -Drink flows down surface through ridges of mold

Our third design we adapted from a simple pourer found online, which is as follows:

Design 3:
- -Simple holder for cups
- -Small, short paths for liquids to follow
- -Found at GreenField Judicature

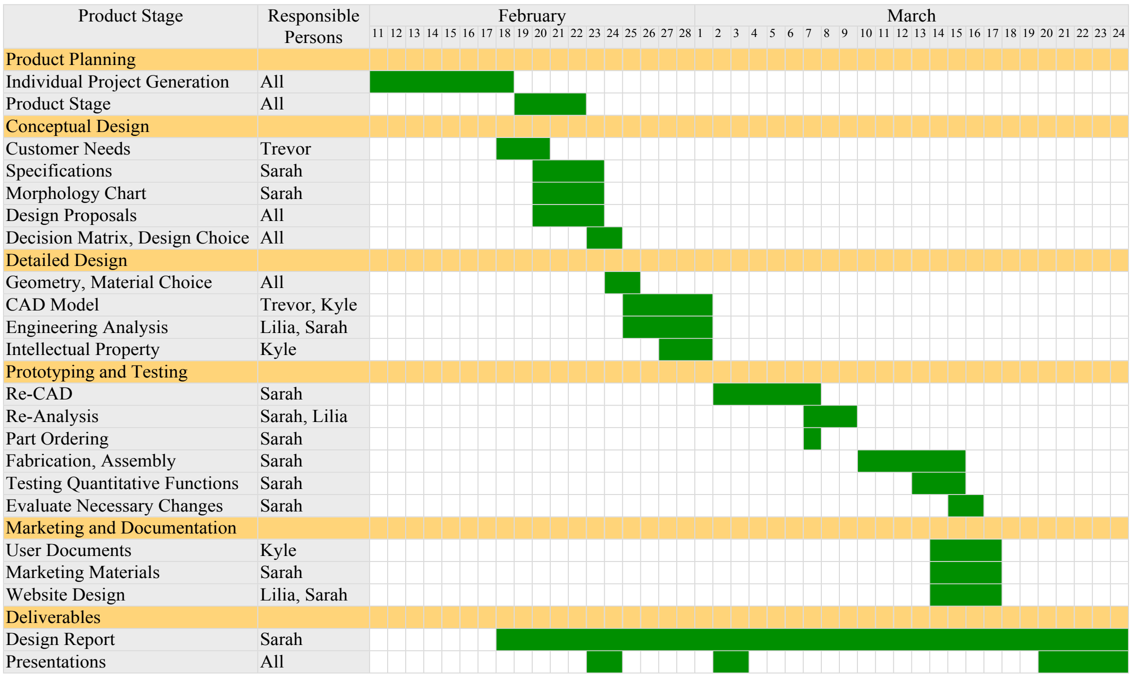
To choose between these three designs, we put together a Pugh Decision Matrix:

Criteria	Importance (%)	Design 1	Design 2	Design 3
Adjustability	10	10	5	0
Complexity	25	6	2	8
Stability	10	4	4	6
Ease to clean	5	5	5	6
Cooling ability	10	10	5	0
Size	5	8	8	8
Appearance	20	9	9	5
Mixability	5	10	0	8
Cost	10	6	4	9
Total Score		6.85	4.75	4.70

Week 2 Update:

After finding out abut size limits on 3D printing, we chose to continue with Design 1, but scale down to only accommodate smaller glasses, and change the funnel from a large mixing chamber to a smaller pouring area.

Project Plan: Gantt Chart



Look! It’s all green!

Section 4: Detailed Design and Analysis

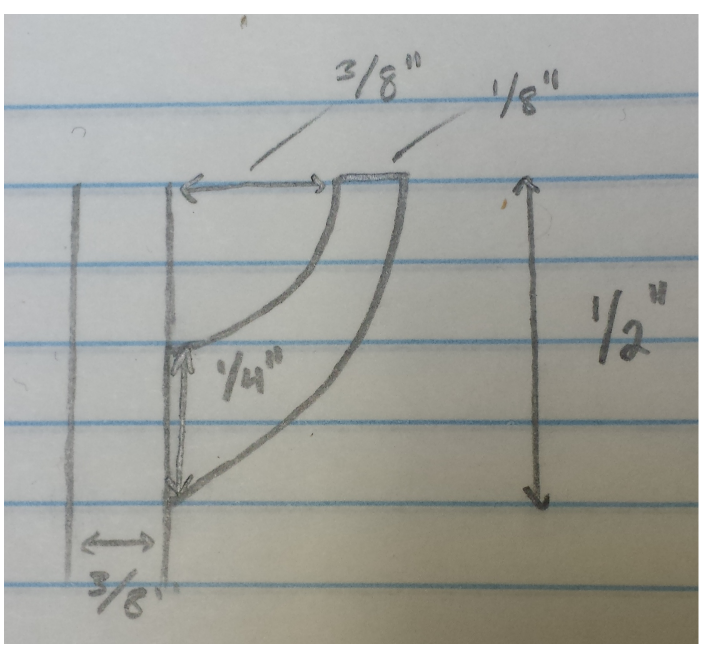
Iteration One

Geometries:

When our group met to discuss our project, we identified a list of each dimension we would have to specify. Here is a table listing those dimensions and the values we chose.

Dimension	Size (inches)
Stand Height (Base - Arm)	1/4 - 4
Main Chamber Height	5
Funnel Height	3/4
Height Separating Chamber/Funnel	1/4
Stand Arm - Hollow or Solid	Hollow, wall thickness = 3/16
Width Stand (Base-Arm)	6 - 1
Width Main Chamber (Outer-Inner)	5 - 4+2/8
Width Funnel (Top-Bottom)	2 - 1
Width Funnel Wall	3/16
Number of Tube Revolutions	1.5

And below is a drawing of the shape of our tube/channel:



Materials:

Originally our thought was that we would use ceramic, as this was the only available food safe material on Shapeways. However, we have now figured out that we could design our product in plastic, and then coat it with an FDA approved lacquer post production. If we do use plastic, we are unsure whether we would use plastic provided from Professor Lipson's lab (i.e. the plastic we prototype with) or whether we would order the piece off Shapeways.

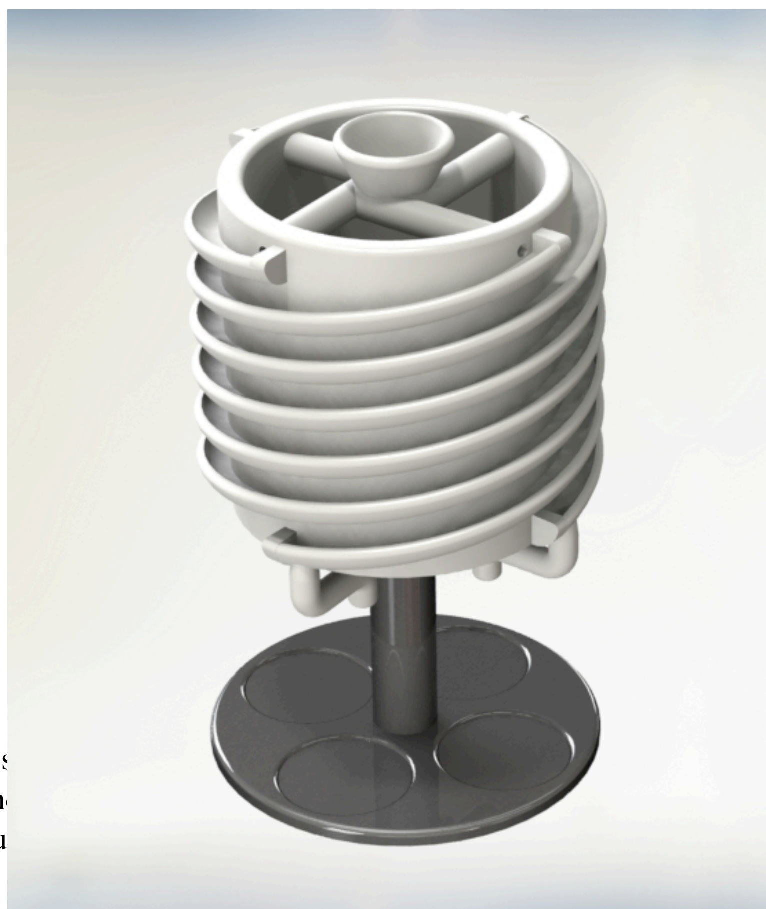
Production:

At first, we planned to make our entire product on a 3D printer, though our cost analysis states why this looks infeasible moving forwards. Though the below design is based off the 3D printed model, we plan to move forward using many more standard parts purchased from McMaster Carr.

CAD Model:

To access the Solidworks files of our 3D printed piece, please go to: goo.gl/CzB2GO

We produced the model of our product on Solidworks. Here is a photorealistic rendering:



The dimens ... ere are two parts,
the base an ... lemonstrated with
this close u

Engineering Analyses:

Conclusions are highlighted. Analysis 5 assumes the material is plastic.

These analyses utilize the following material properties for ceramic:
Data collected from CES Material Universe: glass ceramic - 9658

Density: 0.0910 lb/in^3
Young's Modulus: 9.1e6 psi
Shear modulus: 3.8e6 psi
Poisson's ratio: 0.2
Bulk modulus: 5.3e6 psi
Yield strength: 10e3 psi
Tensile strength: 10e3 psi
Compressive strength: 120e3 psi
Flexural strength: 15e3 psi (use flexural strength when selecting materials for strength-limited designs loaded in bending)
Thermo conductivity: 1 BTU.ft/hr.ft^2. °F
Specific heat capacity: 0.2 BTU/lb. °F
Thermo expansion coefficient: 5e-6 /°F

1. Stress analysis of funnel & bucket connection (most fragile part)

Volume of the funnel (inner):

1/3*(pi*1^2)*(3/2)- 1/3*(pi*0.5^2)*(3/4)= 1.4 in^3
Assume filled with water
Water density at room temperature = 0.036lb/in^3
Liquid mass: (0.036lb/in^3)*(1.4 in^3) = 0.0504 lb = 0.023 kg

Funnel wall thickness: 3/16"
Volume of the funnel (outer):
1/3*(pi*(1+3/16)^2)*(3/2)- 1/3*(pi*(0.5+3/16)^2)*(3/4)= 1.84 in^3
Volume of funnel bottom: pi*0.5^2*3/16 = 0.15 in^3
Funnel volume(itself) = outer-inner+bottom = 1.84 - 1.4 + 0.15 = 0.6 in^3
Mass of the funnel = (0.0910 lb/in^3)* (0.6 in^3) = 0.55 lb

Total mass from the top: 0.55 lb+0.0504 lb = 0.6 lb = 0.27 kg
Force exerted on connection: (0.27+0.023) * 9.8 = 2.9 N
4 connection supports each have : 0.7 N
Tube cross section area: pi*((1/8)^2-(1/16)^2)=0.0368in^2= 0.00093472m
Compressive stress: 0.7/sqrt(2)/ 0.00093472 = 530 Pa = 0.08 psi

Bending stress: M*(R)/I
L = 2in = 0.508 m
Moment M = FL = (2.9/4) N * 0.508 m = 0.37 Nm
R = 1/8 in = 0.0032 m
I = pi/2*((1/8)^4-(1/16)^4) = 3.6e-4 in^4 = 1.5e-10 m^4
Bending stress = MR/I = 0.37*0.0032/1.5e-10 = 7.9e6 Pa = 1146 psi < 15e3 psi

Both bending stress and compressive stress are well below flexural strength and compressive strength.

2. Moment Required to Knock Pourer Over

Assumes our group uses the maximum amount of plastic that fits to our budget.
Max Volume of Material ~ 10 in^3 = 165 cm^3
Max Mass of Plastic ~ 330 g
Max Weight of Plastic ~ 3.3 N
Max Radius of Force = 9.78 in = .2484 m
(F)(.2484m) = (3.3 N)(.075m) => F ~ 1.00 N or M = .248 Nm

This makes our pourer about 3 times as stable as a standard coffee mug!

3. Max Fluid Flow Through Funnel

Bernoulli's Equation:
(P surface above) + (density*g*h) + (.5)(density)(v of funnel)^2 =
(P surface below) + (.5)(density)(v of tube)^2
Also, (v funnel) = (4*area tube / area funnel base)(v tube) = .25 v of tube

V tube = .736 m/s maximum [i.e. not including friction]

4. Max Fluid Flow Through Tube

Assume only forces on fluid are gravity and drag.

Horizontal tube length = pi*(5 in)*(1.5 revolutions) = .598 m
Vertical tube length = 5.5 in = .140 m
Angle of tube = 13.2 degrees

F, gravity along tube = (1g/cm^3)(10m/s^2)sin(13.2)(area=.605 cm^2) = .00136 N/cm
F, drag against tube = (.5)(1g/cm^3)(c ~ 1)(v^2)(circ = 3.81 cm) = .00191 kg/cm^2 * v^2

Terminal velocity ~ .1 m/s Time to flow ~ 6s

5. Thermodynamics (using plastic)

Simplify by assuming ice and fluid are separated by flat wall.

Average thermoconductivity of plastic ~ .25 W/mK
Cooling 1.5 oz of liquid in 6s, with approximately .01 m^2 are of contact

Q/t = kA(T difference)/(thickness) = (.25 W/mK)(.01 m^2)(~8 F)/(.125 in) = 3.9 W

.6 J removed per gram of water, easily can counteract the warming effect of room temperature air, would only cool on the range of .5-1 degree F.

Cost Analysis:

Our current CAD model uses ~60 cubic inches of material. Assuming we printed this as cheaply as possible, that is, using ceramic, this would cost >300$ to create. Therefor, we will have to make dramatic changes to our design in the next few days, before we begin prototyping. Simply printing less material is not much of an option. We could only thin down the walls so much, and to counteract this we would need to print in stronger materials (plastic.) So our best option moving forwards is most likely to be 3D printing less, while incorporating many more standard bought parts. This could include a laser printed base with screw rod attachment (the whole base could likely be made this way for less than 10 dollars.) We could also use foodsafe plastic tubing purchased off McMaster Carr rather than building our own. Using these sorts of methods, we believe the price could easily be brought down below 100 dollars, hopefully less.

<u>Iteration 2</u>

Changes to Design / Moving from Iteration 1 to Iteration 2:

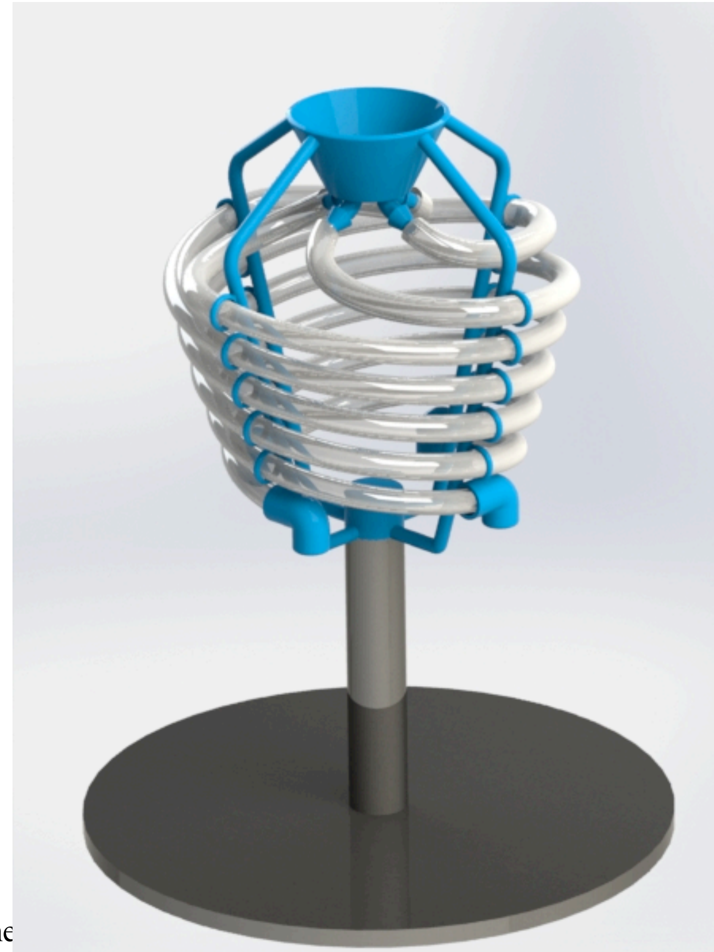
Looking at the Cost Analysis for Design Iteration 1, it's immediately obvious that the design in this form is infeasible. A body and stand made fully from ceramic simply use too much material. Even with plastic, the bucket and tubes are still too voluminous to design. Thus, our group looked to use more parts that can be purchased at prices from being mass produced, rather than creating our own. Sarah came up with a design that is a sort of skeleton/frame which holds plastic tubing in a helical pattern. The base, meanwhile, consists of a laser cut disc attached to a nylon rod via thermoplastic insert and steel stud. She chose the nylon rod because it has a feel more similar to the 3D printed material than, say aluminum or steel, and the length because it held the spout off the base high enough for many sizes of cups, while not dwarfing the main piece of the design. The tubes' diameters were chosen based on low cost and small turning radius, for which ID 1/4" OD 3/8" seemed ideal. Finally, the barbed tube fitting was designed into the 3D printed funnel because attaching purchased ones would be very difficult; the 3D printed plastic cannot have reliable threads, and may be difficult to tap.

The advantages of this design are its low cost, sleek look, and small volume. However, there a couple disadvantages. The first is that, by using different parts from McMaster Carr, we run the risk of having a less uniform product (i.e. one that seems more homemade than properly manufactured.) The second is that the skeleton frame is weak compared to a full bucket and channel. Still, the other designs we thought up (such as using a metal rod as a bucket with plastic tubing wrapped around) didn't solve these issues. Iteration 2 maximized the unity of our product while remaining within project constraints.

CAD Model :

To access the Solidworks file of our 3D printed piece, please go to: goo.gl/CzB2GO

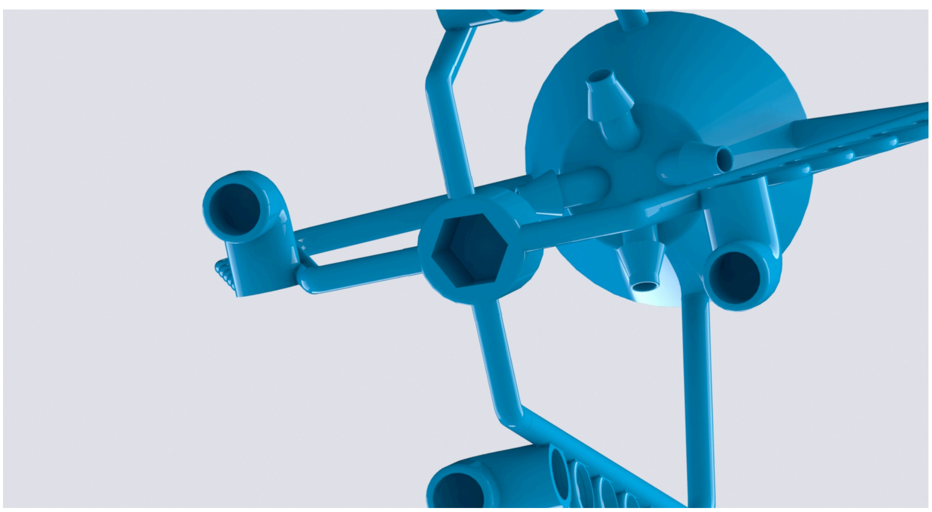
This CAD model describes our ideal prototype. First we show a renderring of the entire piece, though note that the stand, base, and tubes are not 3D printed:



This view of only the l attachments that securely hold plastic tubing while creating a watertight seal:

Here is some detail on the tube holding rings and the bottom piece that turns the liquid flow into a downwards direction:

Final utout that allows a the frame to sit snuggly on top of a hex rod extending up from the base plate:



Materials:

This product will be printed in Shapeways “strong and flexible plastic,” polished and in color. We chose this plastic because of its versatility, strength, and low cost. Though the polishing and color additions puts a few more limitations on us (such as slightly increased price and smaller size boundaries) we think it adds significant value to our product, including aesthetics, feel, and precision.Our design fulfills all of Shapeways limitations for printing in this material, such as bounding box size, wall thickness, etc.

Other materials in this product were determined by availability of McMaster Carr’s parts.

Assembly Documentation:

Until now, we've only shown the 3D printed part of our product. However, this clearly cannot work alone. First, the liquid will be transported from funnel to spout via FDA approved plastic tubing. The frame above was designed specifically to fit this tubing's diameters and turn radius. The tubing will fit snuggly onto the funnel tapers, then form a helical structure by passing through the rings of the structure, and finally into the bottom spouts. For extra support, a small amount of silicone sealant will be placed in the frame rings to prevent the tubes from shifting.

The frame must also be held above a table (and cups.) To do this, we will laser cut a large, round acrylic base. Then, a thermoplastic insert will be placed in the center of the acrylic, and a threaded steel stud will interface between this insert and a nylon hex standoff. The frame has a hexagonal "cup" that will snuggly hold it on the standoff. With this setup, the frame should stand slightly more than three inches above the tabletop. We chose a nylon standoff over a metal one because of two factors. The first was price, as the nylon was more than 50% cheaper than a comparable metal counterpart. The second was feel and product integration. Nylon has a texture and look more similar to plastic than steel. Because of this, we believe that the nylon makes our product appear more uniform.

Cost Analysis:

We show a table that documents the final cost of our product (that is, not including pieces we don't use):

Item	Source	Price/Unit	Unit	Cost
Frame	Shapeways	$2.25 + $1.50/cm^3	39.17 cm^3	$61.00
Laser Cut Base	Cornell Lab	Complex, calculated per piece	1 piece	$7.97
Tubing	McMaster Carr	$1.39 / ft	6.5 ft	$9.04
Silicone Sealant	McMaster Carr	$3.95 / tube	10% tube	$0.40
Thermoplastic Insert	McMaster Carr	$9.15/ 25 pcs.	1 unit	$0.37
Steel Stud	McMaster Carr	$1.07 / unit	1 unit	$1.07
Nylon Standoff	McMaster Carr	$8.15 / unit	1 unit	$8.15

This gives us a total cost of $88.00, which is below our total budget of 100 dollars. Though more expensive than we wanted for this product, we know that when mass produced, this product could be much more cost efficient.

Geometries:

The CAD model and part availability determined many of the geometries in our product. Here are some of the key frame dimensions:

Dimension	Size (inches)
Frame Overall Height	5.75
Funnel Height	1
Space - Top Ring to Bottom Funnel	0.75
Frame Diameter at Top Ring	5
Frame Diameter at Bottom Ring	2.5
Funnel Diameter (Top-Bottom)	2 - 1
Hex Cutout Depth	0.40
Hex Cutout Width	0.50
Funnel Wall Thickness	0.08
Frame Rod Diameter	0.20
Hex Holder Diameter	0.40
Ring Inner Diameter	0.375
Ring Outer Diameter	0.50
Ring Depth	0.10

This shorter list details the shape of our laser cut base:

Dimension	Size (inches)
Outer Diameter	4.00
Inner Diameter	0.175

Engineering Analyses:

Plastic Properties:

$\rho = 1.51 \dfrac{g}{cm^3}$

Drag Coefficient, Water on Plastic ≈ 1

Allowable (Tensile) Stress $= 40MPa$

Allowable Shear $= .6 \cdot$ Allowable Stress $= 24MPa$

Water Properties:

$\rho = 1 \dfrac{g}{cm^3}$

Other properties and dimensions are listed in problems or in geometry section.

1 Moment to Begin Knocking Pourer Over

Material Volume $= 2.4in^3 = 39cm^3$

Material Mass $= \rho \cdot V = 59g$

Pourer Weight $= g \cdot m = .58N$

Adding in Weight of Stand, Pourer Weight $\approx 1.0N$

Maximum Radius of Force $= \sqrt{(base)^2 + (height)^2} = 21.4cm$

Force Required to Overcome Moment of Weight $= .47N$

Using average coffee mug dimensions: 2 in radius, 6 in height, and 150 g weight, we find our pourer slightly more stable than the mug!

2 Maximum Fluid Flow Through Funnel

Bernoulli's Equation:

(Pressure, Surface Above) + ($\rho \cdot g \cdot$ fluid depth) + ($1/2 \cdot \rho \cdot$ Funnel Velocity^2) =

(Pressure, Surface Below) + ($1/2 \cdot \rho \cdot$ Tube Velocity^2)

We also know: Volume of Funnel $= \dfrac{4 \cdot \text{Tube Area} \cdot \text{Tube Velocity}}{\text{Funnel Base Area}} = \dfrac{\text{Tube Velocity}}{4}$

Tube Velocity $= .736 \dfrac{m}{s}$ maximum, that is, not including friction.

3 Maximum Fluid Flow Through Tube

Assumes only forces on fluid are gravity and drag.
Horizontal Tube Length $= \pi \cdot$ helix diameter $\cdot$ 1.5 revolutions $= .479m$
Vertical Tube Length $=$ helix height $= .127m$
Angle of Tube $= arctan\left(\frac{.127m}{.479m}\right)$
Tube Area $= \pi \cdot radius^2 = .317cm^2$
Tube Circumference $= \pi \cdot d = 1.99cm$

Force of Gravity Along Tube $= \rho \cdot g \cdot sin(\theta) \cdot A = .000814\frac{N}{cm}$
Force of Drag Along Tube $= 1/2 \cdot \rho \cdot c \cdot v^2 \cdot C = .000995\frac{kg}{cm^2} \cdot v^2$

Terminal Velocity $\approx .1\frac{m}{s}$
Time to Flow $\approx 5s$

4 Strength of Funnel Connection

$I = \frac{\pi}{4} \cdot$ connection radius^4
Allowable Stress $= \frac{M \cdot c}{I}$, thus, $M = .5Nm$ for each rod
Angle of Connecting Rods $= 31$ degrees
Length of Rod $= 7.4cm$

Vertical Force Required to Produce Moment $= \frac{M}{cos(31) \cdot length} = 7.9N$
Force Required Over All Rods $= 31.5N$

Mass of Funnel $= (\approx 5in^3) \cdot \rho = 12.3g$
Mass of Liquid in Funnel $= \pi \cdot$ average radius$^2 \cdot$ depth $\cdot \rho = 28g$
Total Weight Supported at Funnel $= .4N$

The frame should support the weight of the funnel with a factor of safety greater than fifty!

5 Moment and Stress on Tube Holders

Approximate Holder as Beam of Dimensions: $.1in \times .375in$ with weight acting at $x = .25in$

Allowable Stress $= \dfrac{M \cdot c}{I} = \dfrac{Force \cdot distance \cdot c}{I}$

This gives us, $Force = 242N$

Weight of Tube $\approx$ Weight of Water Held

Weight Supported $= 2 \cdot$ Weight of Water Between Two Holders (Maximum at Top)

Thus Weight Supported $< .1N$

The load of tubes filled with water is significantly less than the load that would cause supports to bend and break.

6 Shear Force on Tube Holders

Connection Area $= width \cdot height = .1in \cdot .375in = .242cm^2$

Shear Allowable $= .6 \cdot$ Tensile Strength $= 30MPa$

Maximum Shearing Load $=$ Connection Area $\cdot$ Shear Allowable $= 726N$

From previous calculation, Supported Weight $< .1N$

The load of the tubes filled with water is significantly less than the load which would cause supports to shear.

Iteration 2.1

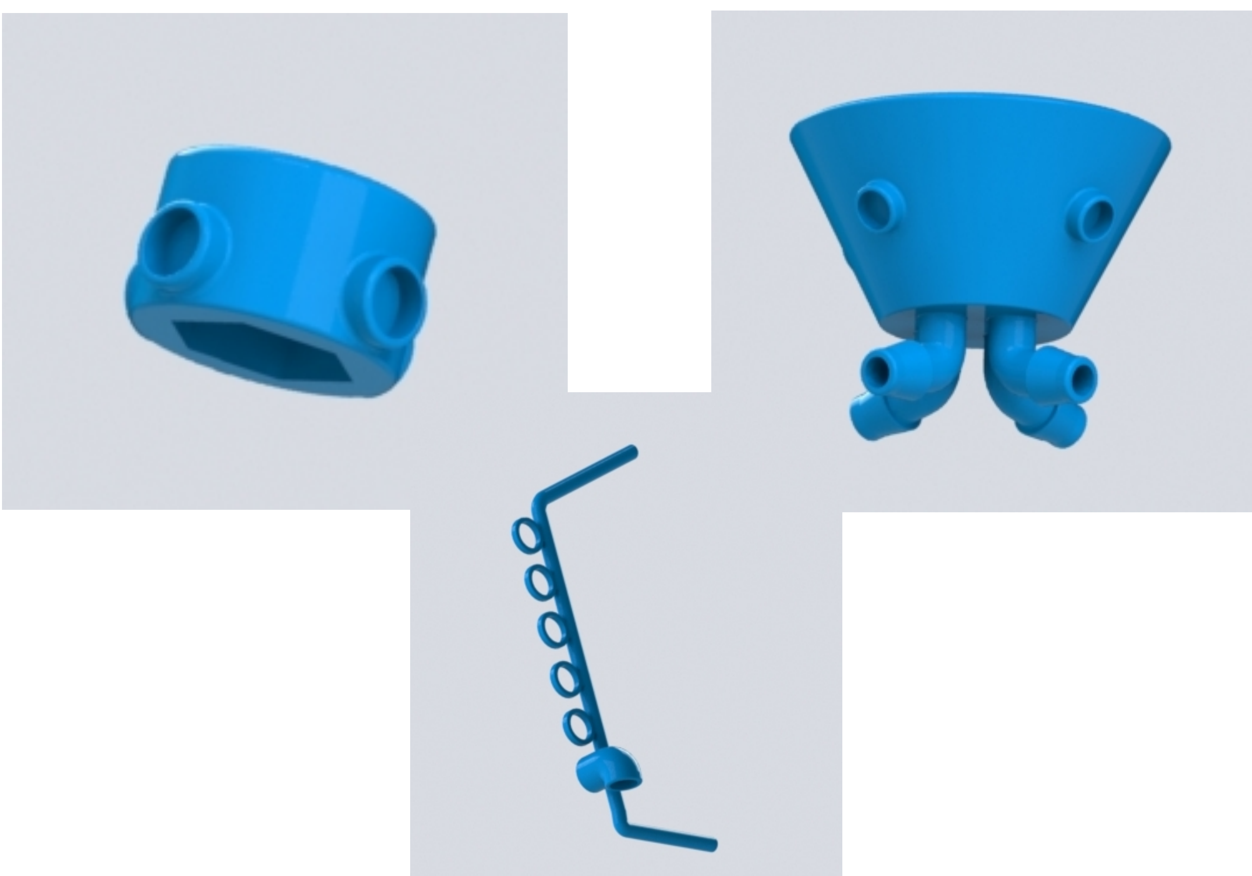
Changes to Design / Moving from Iteration 2 to Iteration 2.1:

Iteration 2.1 is named such because it doesn't totally represent a new design. On March 10th we were informed that our design was "too spindly" to be printed in the Cornell Lab printers, as it would take to much time that needed to be distributed among other teams. Thus, Iteration 2.1 is the splitting up of our piece into multiple parts that can be glued together to form our original design. To do this, we had to copy the geometries of the piece made before. We split the design into six parts: the funnel with tube attachments, the bottom piece that sits the piece on the base, and the four "arms" which support the plastic tubing. The funnel and the bottom piece were given small "sleeves" which the arms can easily slip and be glued into. We see Iteration 2.1 as only a prototype model, that is, our final 3D printed piece would be ordered from Shapeways as the unibody design from Iteration 2.

CAD Model:

To access the Solidworks file of our 3D printed piece, please go to: goo.gl/CzB2GO

Below are renderrings of the three unique parts described above:



Other Aspects of Design:

The geometries of this design are the same as those of Iteration 2. The exception is the addition of "sleeves" which hold the frame arms onto the funnel and base adapter. These sleeves have ID of 0.2in, OD of 0.28in, and depth of 0.2in, each time perpendicular to the surface they sit on. The assembly of the design is also similar to above, with the exception that silicone glue must be inserted between the arms and sleeves of attaching pieces to hold them together. The cost of this design is detailed in the Prototyping Budget Record in Section 5, below, as this iteration's costs are only taken into the account of the prototyping budget. Finally, the engineering analyses are the same for this design.

Iteration 2.2

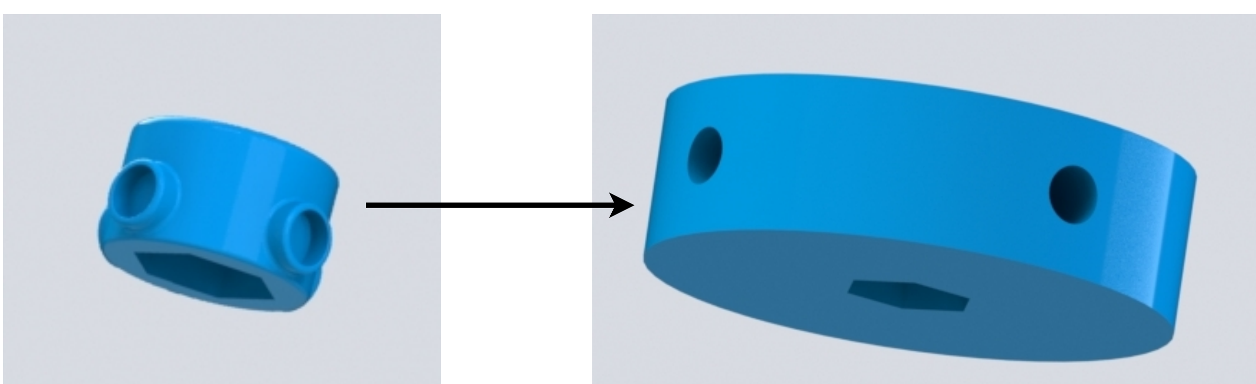
Changes to Design / Moving from Iteration 2.1 to Iteration 2.2:

When we received our first batch of 3D printed pieces, we started trying to assemble them. It quickly became clear that the base connecting piece's "sleeves" (the small rings that were meant to hold the arms attached via glue) were far too small. Thus, we quickly redesigned a new part. It has more of a disk with mock drilled holes, approximately 10x longer than those on Iteration 2.1. This time, the arms fit more snuggly into the holes and were quite well supported, especially so when glued.

CAD Model:

The Solidworks file for this piece can be found at: goo.gl/CzB2GO

This CAD renderring simply shows the new base adapter part, side by side with the part it replaced.



Other Aspects of Design:

Once again, the geometries and analyses of this design are unchanged, with the exception that the circular piece of design is now 1.0" in diameter, opposed to 0.4" as before. Thus, the sleeves are extruded into this disc, instead of extruded out as before. The cost analysis can again be found in the Prototyping Budget Record in Section 5.

Intellectual Property:

In an effort to understand the intellectual property landscape our group was working in, Kyle did some research on the website of the US Patent and Trademark Office. He searched many terms relevant to our drink fountain. These terms returned either no results or irrelevant results: Multiple Shot Pourer, Multiple Shot Dispenser, Shot Pourer, Multiple Drink Dispenser, Multiple Drink Pourer, Drink Slide, Volumetric Dispenser, and Drink Pourer.

However, there were two relevant results that somehow compared to our idea. The first was US Patent 2012021152 - Liquid Dispenser. This product uses a funnel connected to a flexible tube connected to a valve ending for precise pouring. However, looking at the claims and functions on this patent, this idea serves more as a scientific device to measure and pour small amounts of liquid. It also is largely handheld, rather than freestanding. It is very unlikely we would run into infringement issues with this product.
The other patent we looked into was US Patent 2004101425 - Drink Dispenser with a Columnar Chill Chamber. When we first saw this patent, we were initially worried, as the idea is described very similar to ours. However, as soon as we saw the patent, it was clear that this idea was more used for storing, cooling, and dispensing carbonated beverages that would be in a keg, perhaps in a soda fountain or the like. Because our designs method, scale, and function are so different, we do not think there are infringement issues here.

It may be difficult to patent sections of our idea based on their similarity in function compared to the Kiddush drink fountains we originally saw, and their status as prior art.

Section 5: Production, Testing, and Refinement of Prototype

Refinement of Prototype:

The refinement of our model can be better visualized going through the consecutive Iterations of our design in Section 4. The changes to design feature explains the reasoning behind each change.

Prototyping Budget Record:

With an initial budget of 100 dollars, we cannot waste much money, or we lose the option of creating second prototypes, pieces, or proofs of design. The volume of the CAD model above is slightly less than 2.2 cubic inches of material. Printing on the Creative Machines Lab's Objet printer, the cost of the plastic frame is (2$ + 2.2*12$ =) $28.40. We also printed an extra part later in the week on the Objet which cost $11.67. This brought our laser printing cost to $35.10.

The laser cut base, as an eight inch diameter circle cut with a center hole of diameter .35 in costs us ($1 + .45*5$ + 26.2*$.18) = $7.97. Finally, we purchased the following items from McMaster Carr:

Part	Quantity	Unit	Price
Beverage PVS Tubing, 1/4" ID, 3/8" OD	10	ft.	13.90
Silicone Sealant, clear	1	3 oz. tube	3.95
Brass Heat Set Insert, 1/4"-20 thread, .3" length	1	pack of 25	9.15
Steel Threaded Stud, 1/4"-20 thread, 1" length	2	pack of 1	2.14
Nylon Female Threaded Standoff, 1/2" hex, 4" length, 1/4"-20 thread	1	pack of 1	8.15

for a cost of $37.29. Thus, all of these pieces use a total of $85.33, safely under the $100 prototyping budget.

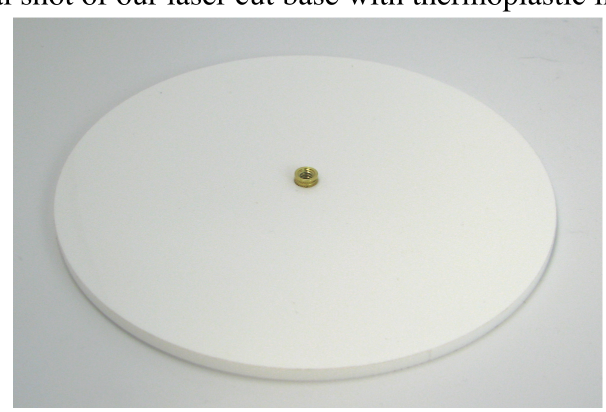
Fabrication and Assembly:

The fabrication for this product is done by multiple sources. The largest, costliest, and most critical piece of our design, the frame, is 3D printed. For prototyping, this will be printed in the Cornell Creative Machines Lab. Our frame design (Iteration 2.1) was submitted on March 11th. The other piece made in-house is the laser cut base, submitted for cutting on March 10th. This simple piece is created, again, in Cornell's labs. All other parts have been purchased from McMaster Carr, ordered on March 8th.

We will assemble these pieces rather simply. The thermoplastic insert will be heat set into the base using a soldering iron. The stud and hex standoff can then be attached by screwing them into the base. The frame then must be assembled by inserting the arms into their sleeves and fixing in that position with a small amount of sealant. The frame can also be made food safe by spreading a dilution of the silicone sealant over the funnel and tube holders. It can then be placed to sit on top of the hex standoff. Finally, plastic tubing must be wrapped neatly through the frame, then supported with a small amount of silicone glue. Here are some pictures of this production.

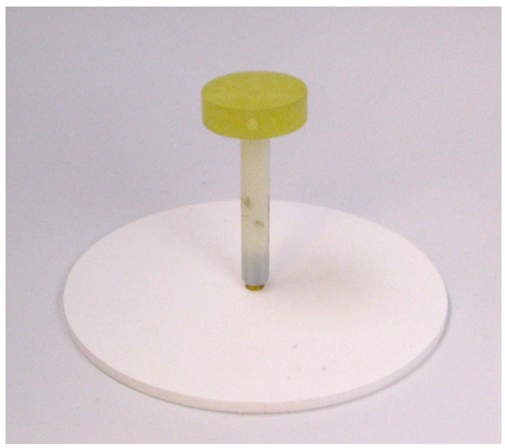
This shows the frame arm, of which we have four.

This is an initial shot of our laser cut base with thermoplastic insert.

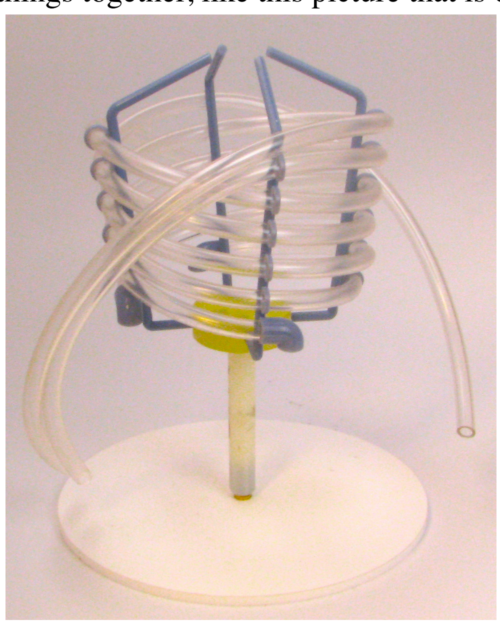


This is the first base connecting piece we attempted to create.

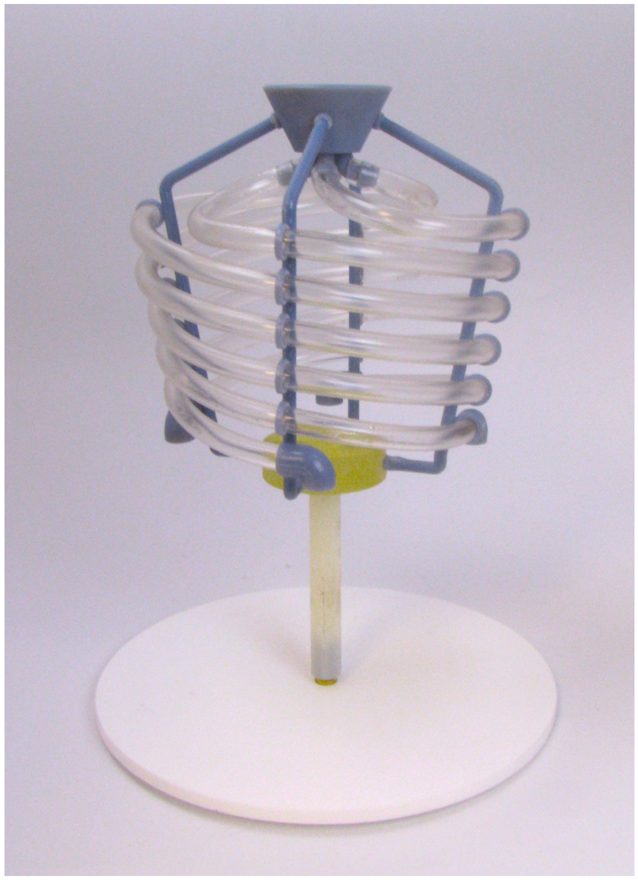
While this is a picture of the base assembled, with the newer base connecting piece.



Then we began putting things together, like this picture that is only missing the funnel.



Finally, when we began glueing, and adding in the funnel, we had our prototype!



More pictures of our product can be found in the final section of this report.

Consumer Assembly and Packaging:

Should a customer order our product, it will be assembled as follows. Our team will order the 3D printed piece from Shapeways, the laser cut base from Cornell, and the pieces (which we don't already have spares of) from McMaster Carr. We will place the thermoplastic insert in the acrylic, and affix the tubes to the frame using sealant. We will also add the food safe coating to the funnel. Then this can all be shipped in a box along with the steel stud and nylon rod, as well as a user manual and any receipts necessary. The only assembly on part of the consumer is screwing the stud and base into the laser cut disc's insert and placing the frame on top of this. Just doing a cursory search for shipping options, we find our product could be shipped in USPS Priority Mail Medium Flat Rate Box 1 to anywhere in the United States for under thirteen dollars.

Usability Criterium:

Though we do not yet have a prototype with which to begin testing, we can document the tests we plan to perform in the coming week.

1. Volume Evaluation - What is the minimum bounding box?
   Measure effective volume of assembled product and unassembled product.
   Tells us what the effective volume for storage (assembled) and shipping (unassembled.)

2. Table Height - What kinds of cups can we pour into?
   Measure clearance.
   Tells us what cups we can list as "compatible."

3. Uniform Pouring Evaluation - How evenly distributed is the liquid?
   Pour drinks into beaker/graduated cylinder and calculate percent difference.
   Tells us if we can expect all drinks to come out equal.

4. Splashback Test - What volume doesn't make it into a cup/glass?
   Pour drinks into cup nested in beaker. Measure volume outside of cup.
   Tells us if there's a problem with tube end velocity/taper/direction.

5. Rinse Test - How easy is it to clean the pourer?
   Pour liquid (like juice; non-water). Then pour water (or soapy water) through fountain. See how many repetitions are needed to adequately clean.
   Tells us if cleaning accessibility is a large concern.

6. Drop Test (Do this last!) - How high a fall can the pourer stand?
   Drop pourer horizontally from heights, increasing to maximum of six feet.
   Tells us if the pourer is sturdy enough to be knocked off a table.

Usability Results:

1. Volume Evaluation
   -For shipping, all of the parts of our piece (that is, with the 3D printed part assembled and the thermoplastic insert sealed, but the rest of the pieces separate), the minimum bounding box is 8"x8"x7.25".
   -Assembled, the bounding box is 8"x8"x10.5"

2. Table Height

-The height of the pouring spouts above the base layer is 4.25”. Thus, we can use the drink fountain to pour into disposable paper “Dixie” cups, shot glasses, espresso cups, and any other container that has a depth less than 4.25”.

3. Uniform Pouring Evaluation
   - -After running 5 runs of 160 mL of liquid through the pourer, the largest difference between maximum and minimum liquid was 3mL (Maximum was 41mL, Minimum was 38 mL). This gives us an acceptable value of 7.5% difference.
   - -Note that this value does assume proper pouring. If user does not pour to center of funnel, or pours too slowly, so that the holes are not always covered, this value changes.

4. Splashback Test - What volume doesn’t make it into a cup/glass?
   - -In all tests for (3), no liquid was found outside of the cups. It does, however, require a bit of tapping to push all the liquid through tubes, that is, a small amount may collect.

5. Rinse Test - How easy is it to clean the pourer?
   - -After pouring cranberry juice through the fountain, and then immediately pouring water, we found no evidence of coloring in the tubes. It is reasonable to say that only one rinse is required to clean the fountain.

6. Drop Test (Do this last!) - How high a fall can the pourer stand?
   - -We have tried knocking the pourer onto its side multiple times, without any signs of bending, fracture, or other fatigue in the fountain structure.
   - -We have not dropped our pourer from significant height (>3ft) yet out of fear that we destroy it before our prototype presentation this coming Monday.

One change to design that these tests suggest is a way to reduce the amount of liquid that collects in the fountain. To do this, we tried to wrap the tubes at a steeper angle, each path only making .75 revolutions around the frame, compared to the original frame. However this only produced a small change in the collecting liquid, while it had a large (negative) impact on the look of the fountain. Therefor, we decide to keep the design, and simply emphasize rotating the fountain as a way to help rid it of liquid after pouring and cleaning.

The other things that we have realized through the tests are the fragility of our prototype. It is immediately obvious that there are parts which suggest weakness, namely in the connection of the funnel to the frame arms. However, because these pieces are only a piece of our prototype design, rather than our final product design, we are not too concerned. The funnel is stable enough so that we do not fear breakage, and it clearly provides proof of our concept.

Competitive Analysis:

As detailed in Section 2: Product Planning and Design 3 in Section 3: Conceptual Design, the most similar product on the market to our pourer is the Kiddush Drink Fountain. Our design is separated from the traditional model in many ways. First off, ours is made out of fun, colorful plastic, as opposed to stainless steel and silver. Our fountain is also fun to watch, with liquid visible as it races around and down the fountain, while the alternative simply divides the liquid to distribute directly below. We market mostly to young people using this as a fun addition to a party, where the Kiddush fountain is a familial piece only used as part of tradition. Finally, our fountain is much cheaper than the alternative; Kiddush fountains run from a couple hundred to a couple thousand dollars, while ours is, at this most expensive production run, around 80 or 90 dollars.

The best way for us to keep and extend this advantage is to highlight these features. Our design is focused on the fun, dynamic aspects of the pouring action. Having the liquid visible is critical, as is the overall look of the piece.

Section 6: Marketing Materials and User Documentation

User Manual:

"The Hurricane" User Manual

MAE 2250 DMS Project

Team 6A – Lab 406

Sections

Section I: Our Product
Section II: Set Up
Section III: Use
Section IV: Cleaning
Section V: Storage

Section I: Our Product

Use this product to pour four drinks at once evenly into shot glasses or small cups in a fun and creative way. This product can be both a centerpiece of a room and be the life of the party. Useful for a broad range of smaller cup sizes as well as liquid temperatures up to 165^{o} Fahrenheit!

Section II: Set Up

Parts included:

1) Top Funnel
2) Four Arms
3) Bottom Joint Piece
4) Stand Shaft
5) Stand Base
6) Four tubes

Assembly Steps:

A. Building Your Frame

****This step may already be completed at purchase****

1) Connect the four arms into the holes at the bottom of the top funnel
2) Connect the four arms into the holes on the side of the bottom Joint piece

B. Connecting Tubes to the Frame

****This step may already be completed at purchase****

1) Plug the first tube into one of the four spouts coming off from the bottom of the funnel

2) Pull the tube so that it is heading in the counterclockwise direction if you were looking from above

3) Pull tube through the top hole of the first bar you cross.

4) Pull the tube through the second hole of the next bar you reach

5) Continue pulling the tube through a lower hole at each bar you cross

6) Once you've gone through the bottom hole of one of the bars, go to the spout on the bottom joint piece corresponding to the next bar and plug the tube into it

7) Repeat steps 1-6 for the next three tubes

C. Assembling and Connecting the Base

1) Screw the bottom of the base stand into the threaded hole of the base plate

2) Stick the top of the base stand into the bottom joint piece

Section III: Use

1) Place a shot glass, dixie cup, or other small beverage holder under each of the four pouring spouts

2) Pour liquid into the top funnel, keeping the water level around a half inch high.

    a. Be careful not to pour too much liquid as the glasses will overflow.

3) Wait for all liquid in the tubes to pour into the glasses

4) Enjoy!

Section IV: Cleaning

Method A: Quick Clean

1) Detach the top half (frame and tubes) from the base.

2) Run warm water through the funnel and tubes over a sink

3) Reconnect the frame and the base

4) Dry by moving pourer in a circular motion and tapping tubes to clear out remaining water.

Method B: Thorough Cleaning

1) Detach the top half (frame and tubes) from the base.
2) Fill a large sink with soap and water
3) Soak the top half in the soapy water
4) Rinse off the outside of the top half
5) Run warm water through the funnel and tubes over the sink
    a. Keep running the water until there is no more soap in the tubes
6) Reconnect the frame and the base

Section V: Storage

For smaller storage volume detach the top half (frame and tubes) from the base. Be sure to dry your pourer before storing in any closed areas (cabinets, closets, etc.) to prevent bacterial growth.

Website:

Our advertising website can be found at (hb3566.wix.com/thehurricane). It includes many of the documents, pictures, videos, and marketing materials found in this report, as well as a way to contact for purchase.

Customer Survey and Results:

We took a survey among college students to see what they thought of our product, to see how we could market it better to customers. The survey had the following questions:

1. Which product name do you like best?
    a. Vortex
    b. Hurricane
    c. Drink Pourer
    d. Tornado
    e. Other Ideas (write in)

2. Would you purchase this product if it were priced reasonably?
    a. Yes
    b. No

3. If yes, what would you say is a reasonable price?
    Write In

4. Do you find this product aesthetically pleasing?
    a. Yes
    b. No

5. What recommendations can you make that would improve the product?
    Write In

6. Please provide a brief review/sentence on what you think of our product.
    Write In

The results we saw were as follows:
    The most popular name was The Hurricane.
    80% would buy this product if it were reasonably priced.
    Mean and median reasonable price is $40.00.

We also received these suggestions and quotes about our product from surveyors as well:

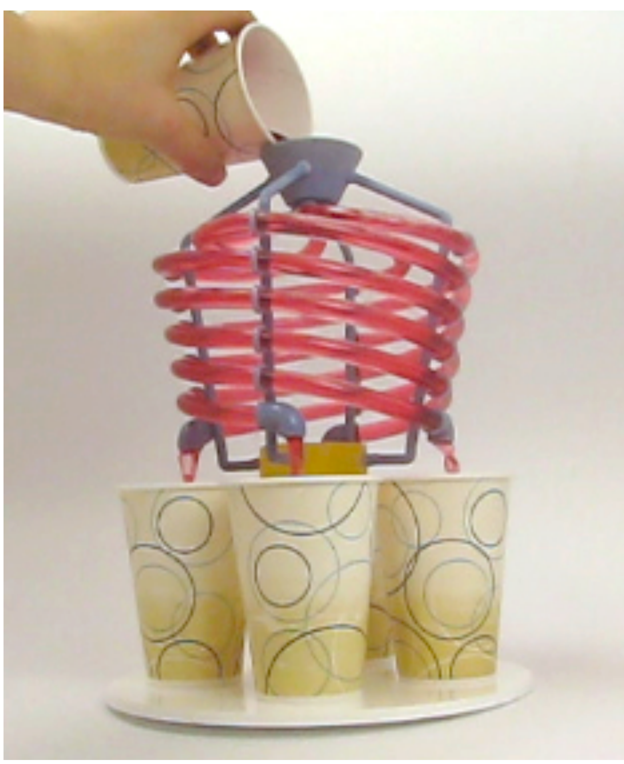
More cups should be filled at once.
Maybe it could be taller so you can fit full size glasses.
More colorz (hic).
Frame could use pizazz, more colors like neon, or the tubes could be colored.

"Fantastic idea! So cool."
"I think the product looks like it would be a lot of fun to use with a group."
"It's like the world's craziest crazy straw."
"I want one for me and one for my dogs. Giving them water is too boring."

From this we gathered that people like our product, but need it too look a little more fun. We hope that this would be achieved with the unibody Shapeways design (Iteration 2) that would look more uniform, as well as being printed in bright color. We also could try to get acrylic printed in a brighter color, perhaps even creating a red, white, and blue color scheme between the base, stand, and frame. We also note that the product cost is a bit higher than consumers wanted, but we maintain that, should our product be mass produced, the cost would fall likely under the one that our users chose.

Marketing Materials:

The following pictures capture our product, both in and out of use.



This picture, meanwhile, is a photorealistic renderring of our product in a bar, a place we imagine it being used by patrons and servers alike.

A marketing and how to video of the product can also be found on our website.