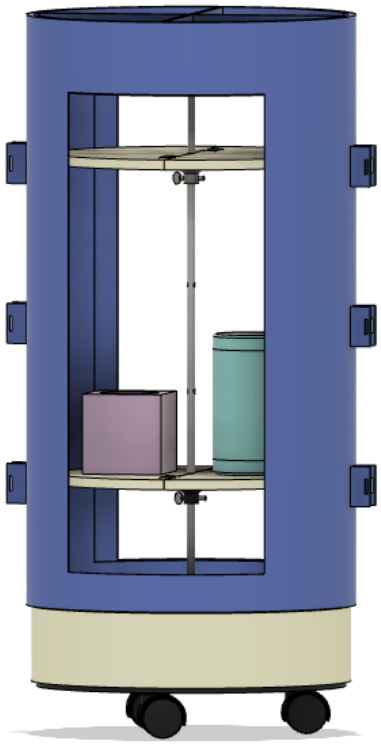


TierClean

Multi-faceted Storage Tower

ME170 Design Team

AB6_03

Team Members

Rohun Patel

Arya Haria

Brian Gertie

Date: 12/10/2021

Product Description and Ideation Process:

Human-centered design is of the utmost importance for engineers at any level. The products that engineers develop are for the sole betterment of society and improving the quality of life for consumers and citizens. Using a human-centered design process allows engineers to cater to the different unmet needs of various peoples.

In our case, we attempted to tackle common issues that many college students in America and across the world face: organization and efficient space-utilization of cleaning supplies and other products in their dormitories. Universities can only provide a specific amount of space for each student due to available space in the dorms and their campus; therefore, we conducted various interviews to gauge the feasibility of the product in mind and see if students would use the so-called product.

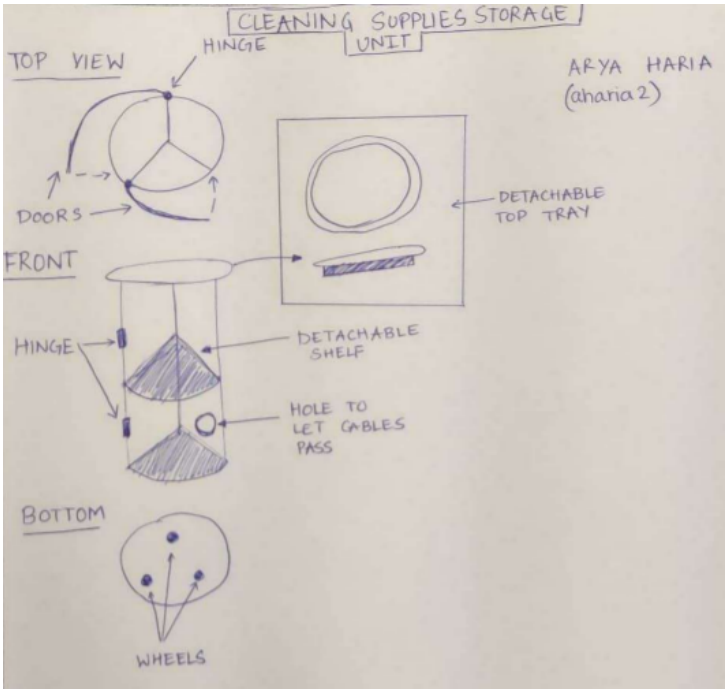
After conducting the interviews, we found that the product in mind would be of great efficacy for college students living in dorms. We learned that students struggle with finding space for storing cleaning supplies and other essential needs for their room. Not only organization, but cleanliness was a recurring issue that students come across. Whether it be ants, dust, cobwebs, or spillages, each requires a different cleaning supply and this can lead to storage and organization issues.

Using the information and insight we received from the interviews, we began the ideation process of our product. Students have a limited amount of space lengthwise and have much more space that could be used going vertically. Therefore, we figured a product using more vertical space would be most efficient. To store different cleaning products, a cylindrical tower with the two best features being shelves, for products with a solid base (i.e. bottles and boxes), and clips for larger cylindrical products (i.e. swiffers or brooms) would be the most efficient. On the inside there would be a rotating mechanism allowing for total 360° usage of space with a center rotating axle which the shelves would connect to. The intended area for the product to be kept would be the corner of the room (evidently it is up to the consumer on where to place it). Therefore to utilize the least amount of space possible, we placed a sliding door to access whatever is stored inside. Another integral part of our ideation process is the product's transportability. We did not want it to be entirely stationary and too heavy. To solve those problems, we decided that we would include wheels on the bottom and use light, but rigid, plastics as the material.

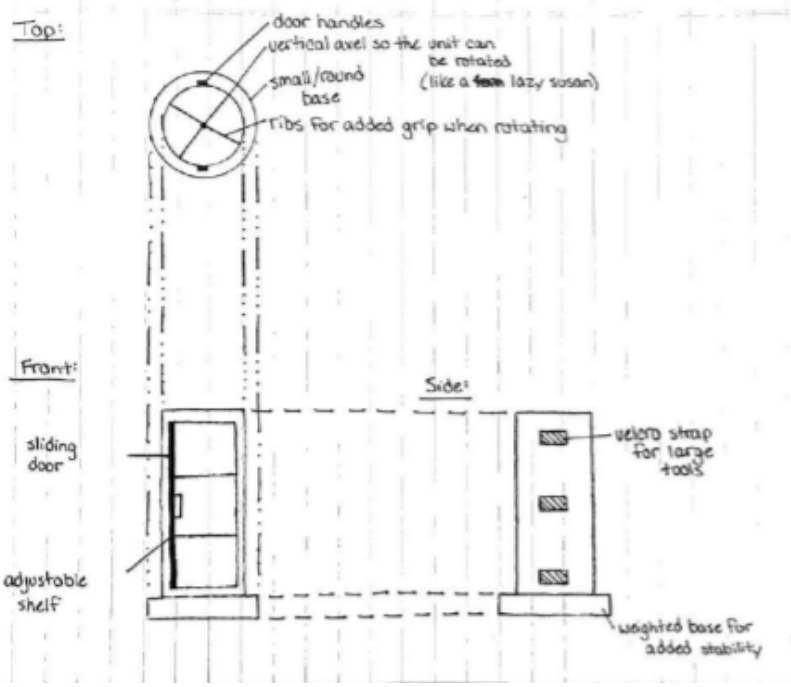
When we conducted the interviews, another comment that repeatedly came up was the price of the product. Students do not have much money to spend because now living on their own, they do not depend on their parents. Our product would meet this important need because of the choice of plastic we would make for the product.

This product would be extremely helpful not only to college students living in dorms or apartments but also to people living in households with more space. The primary competition for this product would be the same price but have fewer features. For example, it would utilize more space, and be stationary with fewer storage options. Therefore, TierClean is the most efficient and practical use of storage for cleaning supplies and products for college students living in dorms and apartments.

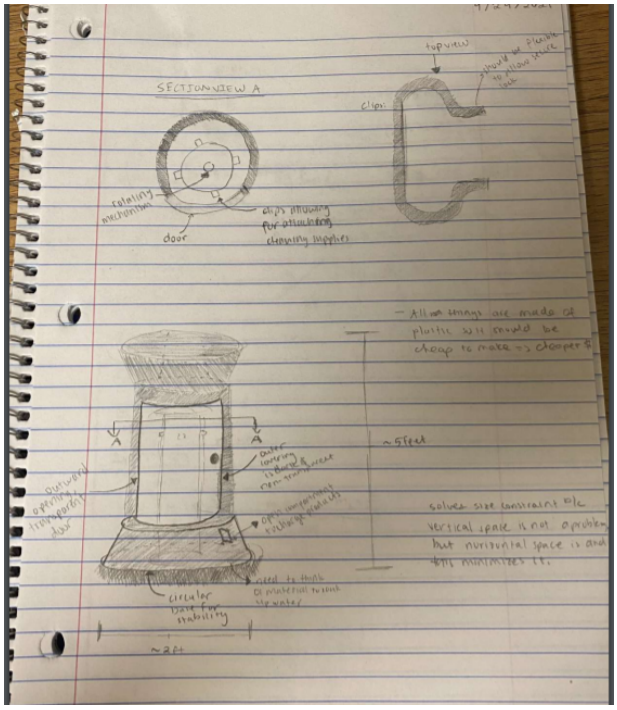
Concept Sketches



This sketch has the basic premise of what we were aiming for. It includes the wheels for optional transportation of the product, the shelves allowing for interior storage, and the doors, which in this case swing outwards. Rather than a rotating mechanism on the inside, it is divided into thirds with two shelves in each section.

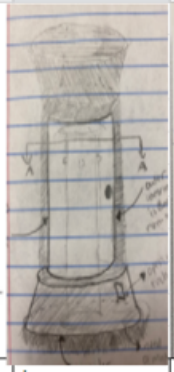
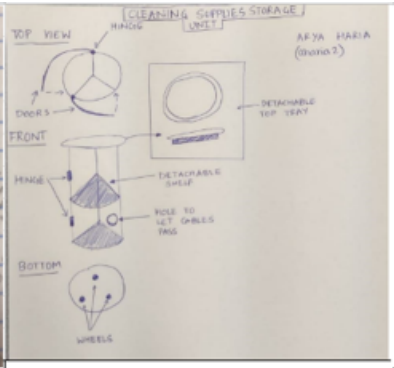
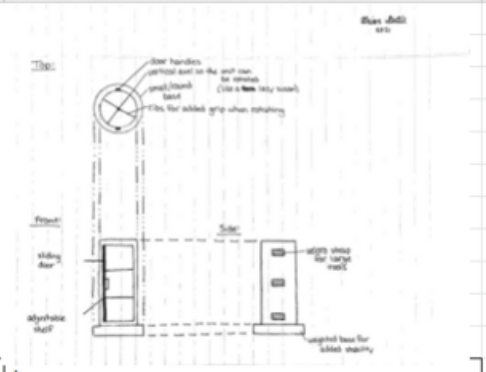


This concept sketch has exterior velcro straps allowing for swiffers and broom-like products to be strapped on. It also has a sliding door rather than an outward-swinging door. On the top, there is a grip to rotate the interior mechanism.



This sketch also has an internal rotating mechanism with clips on the inside. It has a wider base and an outward swinging door.

Pugh Matrix:

				
Performance	+	+	+
Maintenance	S	S	+
Target Costs	+	-	-
Competition	+	S	-
Size	S	+	+
Product Life Span	S	S	S
Environment	S	S	-
Service Life	S	S	S
Quality and Reliability	+	+	+
Packing	-	+	-

To transition to our final sketch, we utilized primarily features from the second two sketches as depicted in the Pugh Matrix. Rather than dividing the interior into thirds, we had shelves that ran around a thinner central axle 360°. The top tray for rotating was implemented to allow for a grip. Also, the velcro straps and wheels from the first and second sketches were implemented.

Product Design Specification:

1. ***Performance***
    1. The tower should hold multiple cleaning supplies and keep them organized
    2. It will allow you to rotate the center so you can access the different parts of the internal mechanism
    3. The door should be simple to open and not require much force
2. ***Environment***
    1. It should be able to withstand liquids used in cleaning and detergents
    2. The door should be able to be used multiple times without experiencing some form of degradation
3. ***Service Life***
    1. Service life should be years
    2. If it can be used for multiple years and is cost-affordable, consumers will be attracted to it
4. ***Maintenance***
    1. The only form of maintenance should be the removal of liquids piling up at the bottom
    2. No additional fees should be necessary to maintain the product
5. ***Target Costs***
    1. Multiple other products only hold smaller cleaning appliances and are targeted around 20-30 dollars
    2. Since ours holds larger cleaning supplies, the target cost should range between 40-50 dollars to prevent it from getting into an excessive range
6. ***Competition***
    1. Other products can hold larger cleaning products, but they are stationary
    2. The mobile ones are only ones that carry smaller products and are more shaped like a basket
    3. Since ours combine the two ideas, the product is ahead of its competition
7. ***Shipping***
    1. It will be shipped in its parts but would be extremely easy to put together (no electrical work to be done)
    2. Could be shipped by land, sea, or air, it does not matter
    3. Would be shipped to whatever distribution company than to the consumer's home or wherever they choose for it to be shipped
8. ***Product Volume (Quantity)***
    1. Want a high volume of products that could be manufactured easily, quickly, and cost-effectively
9. ***Packing***
    1. Parts will be disassembled so would have to wrap each part necessary for the product and ship in a strong cardboard box
    2. Shipping with a cardboard box should be cheap
    3. Surround the parts with bubble wrap to ensure the safety of the product so it does not get damaged during the shipment process
10. ***Manufacturing Facility***
    1. The product does not need a new facility to be made because it uses pre-existing manufacturing processes

2. Initially, will pay to utilize part of a facility then once the product becomes profitable, invest into the specialized plant for the production of solely this product

11. ***Size***
    1. Approximate dimensions would be 8 x 20 x 10 inches
    2. Should at least be able to store a mop of dimensions 4.53 x 18.9 x 6.02 inches

12. Weight
    1. At least 5 PD for sturdiness
    2. No fixed upper limit for the weight as we have wheels to move the product around
    3. Should not be very heavy

13. Aesthetic and Finish
    1. Modern and minimalistic colors
    2. Smooth finish with no sharp edges

14. Materials
    1. Can be made using a sturdy but not very heavy material like acrylonitrile-butadiene-styrene (ABS), acrylics, polyethylene (PE), polypropylene (PP), or polyvinyl chloride (PVC)
    2. The material should have a good life span and should be easy to maintain
    3. The main axle and pin will be stainless steel

15. Product Life Span
    1. 7 years

16. Standards, Specifications, and Legal Aspects
    1. Materials chosen should be safe to store all types of items
    2. Should not be affected extended exposure to water
    3. Should be compliant with OSHA's Hazard Communication Standard and be labeled accordingly

17. Ergonomics
    1. The product should be made easy to use and handle
    2. The doors and all other moving parts should function smoothly
    3. The wheels at the bottom is a specific feature to make the product more ergonomic

18. Customer
    1. The average customer is anybody who uses cleaning supplies
    2. The product is more focused on college students living in dorm rooms
    3. Can be useful for anyone who doesn't want to use up much space to store cleaning supplies

19. Quality and Reliability
    1. Should be of good quality material
    2. The material should not bend or crack easily
    3. The material should be waterproof
    4. Should be sturdy enough to handle a maximum of 100 pounds of force

20. Shelf Life
    1. 5-10 years depending on storage conditions

21. Processes
    1. The product will be likely injection molded

2. Batches of the product will be screened at random to ensure product quality meets expectations
3. Use processes for stainless steel products (main axle, pin)

22. Timescales

1. An official prototype can be made within six weeks
2. Focus group testing can take place within six months
3. The product could be in stores in as little as 18 months

23. Testing

1. The product will be tested to hold at least 10 lbs. on its shelves
2. The product will be tested for smooth opening and closing
3. The product will be tested for smooth rotation

24. Safety

1. The product will have optional childproofing
2. The product will be made from nontoxic plastics

25. Company Constraints

1. The company is, in its current state, a start-up
2. The company lacks funding
3. The company lacks entrepreneurial experience

26. Market Constraints

1. Lots of competition with “storage” in general
2. The product lacks market experience
3. The product lacks a hook/no new technology

27. Patents, Literature, and Product Data

1. The product may qualify for a utility patent
2. The product will undergo examination by a focus group before production

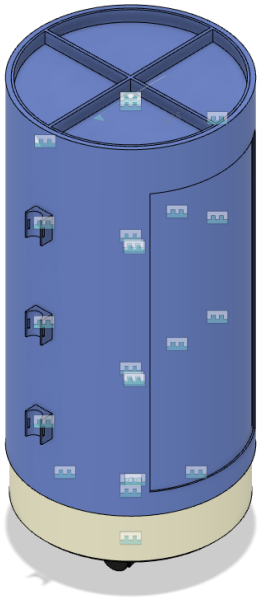
28. Political and Social Implications

1. The materials for the product will be ethically sourced
2. The product itself is gender-neutral and will not be directed towards any sex in particular
3. The product manufacture process will not exploit laborers and be ethically produced

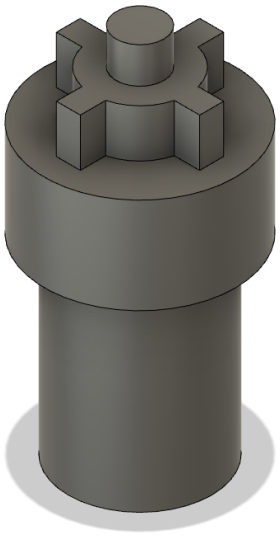
29. Disposal

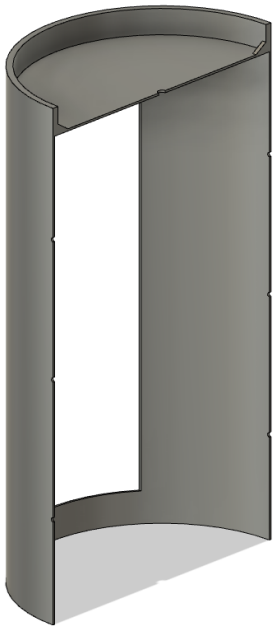
1. The product will be made of mostly recyclable plastics
2. The product will not contain batteries

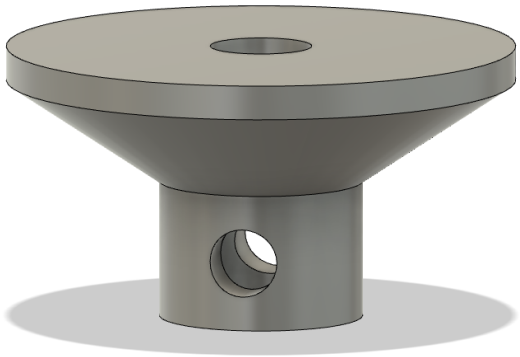
CAD Models - Part and Assembly Models:

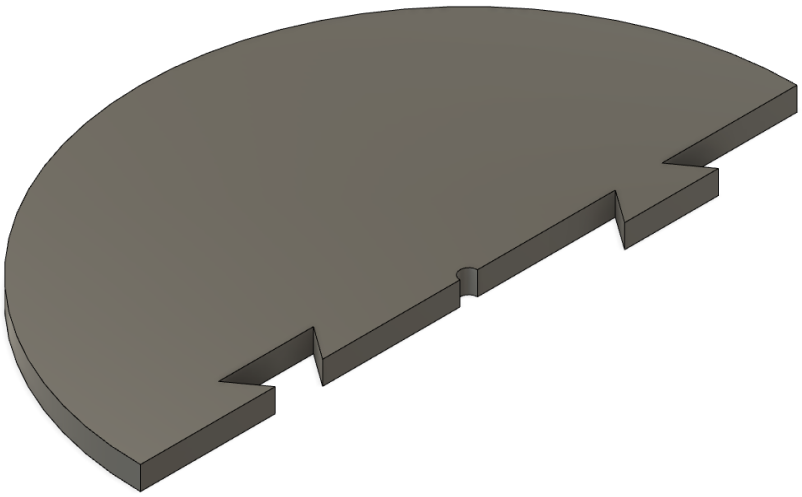


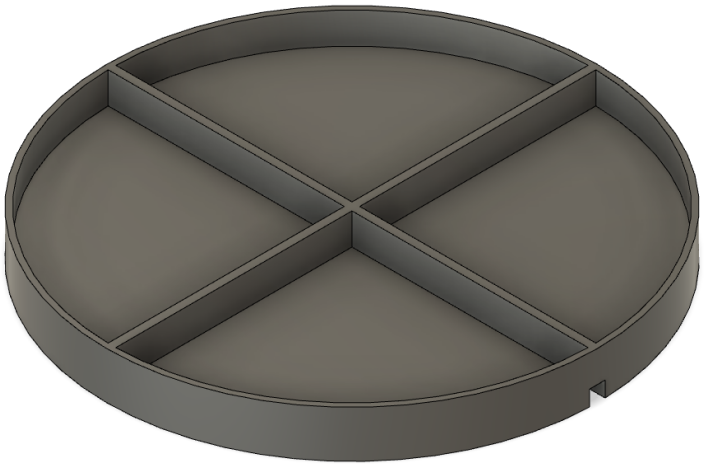
Part Models :

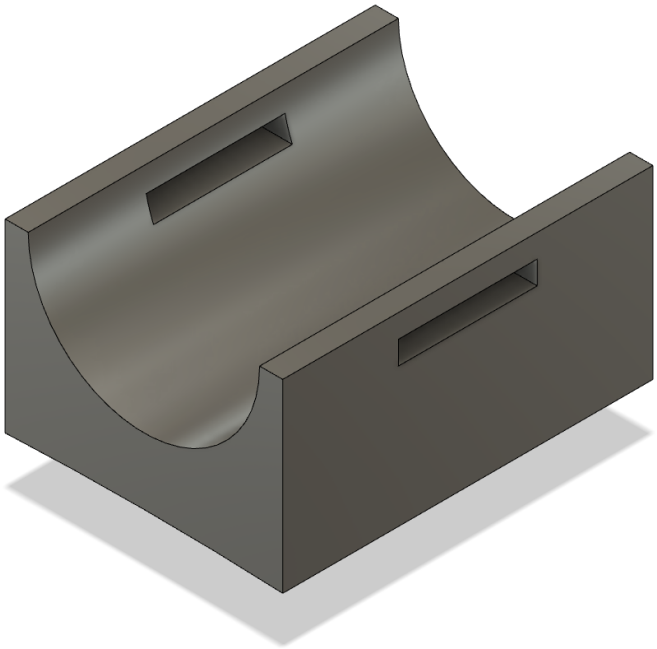




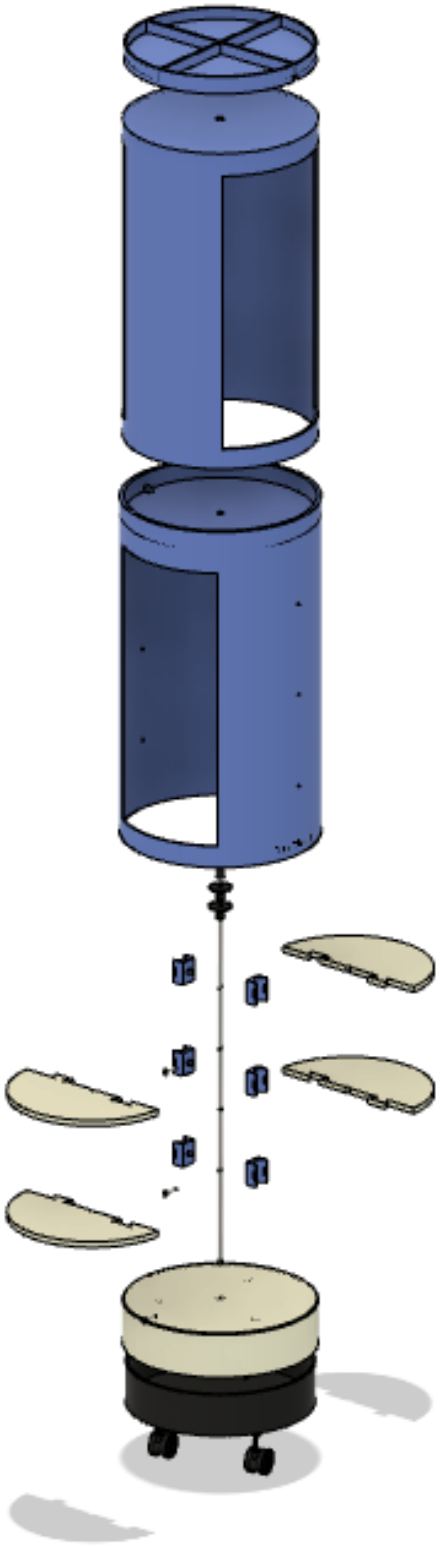


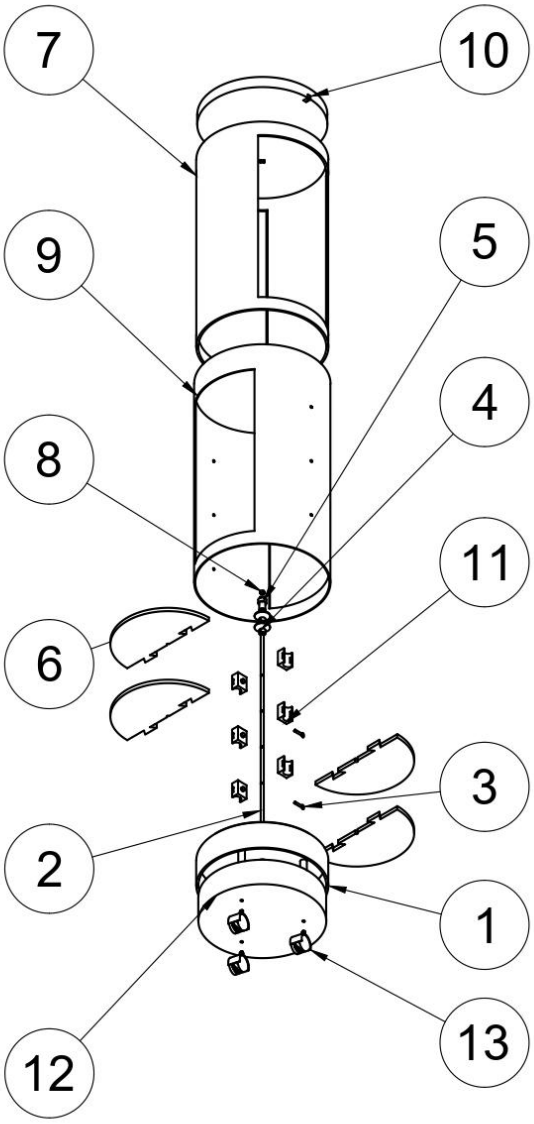






Assembly Model:

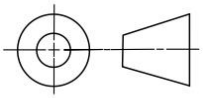




PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	PART 1	PINNED BASE
2	1	PART 2	MAIN AXLE W/ PIN HOLES
3	3	PART 3	PIN
4	2	PART 4	SHELF SLEEVE SUPPORT
5	1	PART 5	AXLE CROWN
6	4	PART 6	SHELF
7	1	PART 7	INNER SHELL
8	1	PART 8	FLANGED BEARING
9	1	PART 9	OUTER SHELL
10	1	PART 10	TOP TRAY
11	6	PART 11	VELCRO CLIP
12	1	PART 12	WHEEL BASE CAP
13	3	PART 13	WHEEL

UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018

THIRD ANGLE PROJECTION



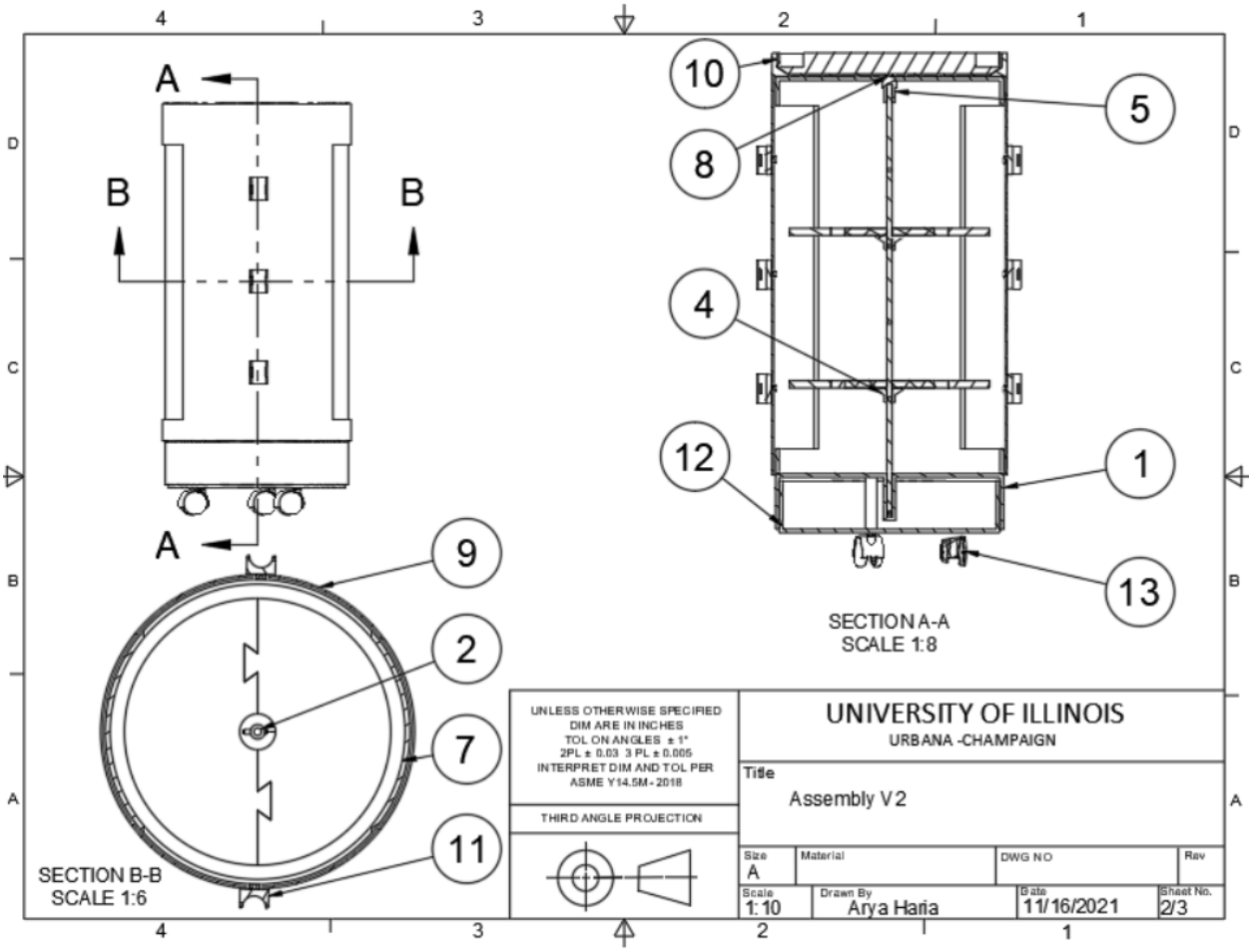
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN

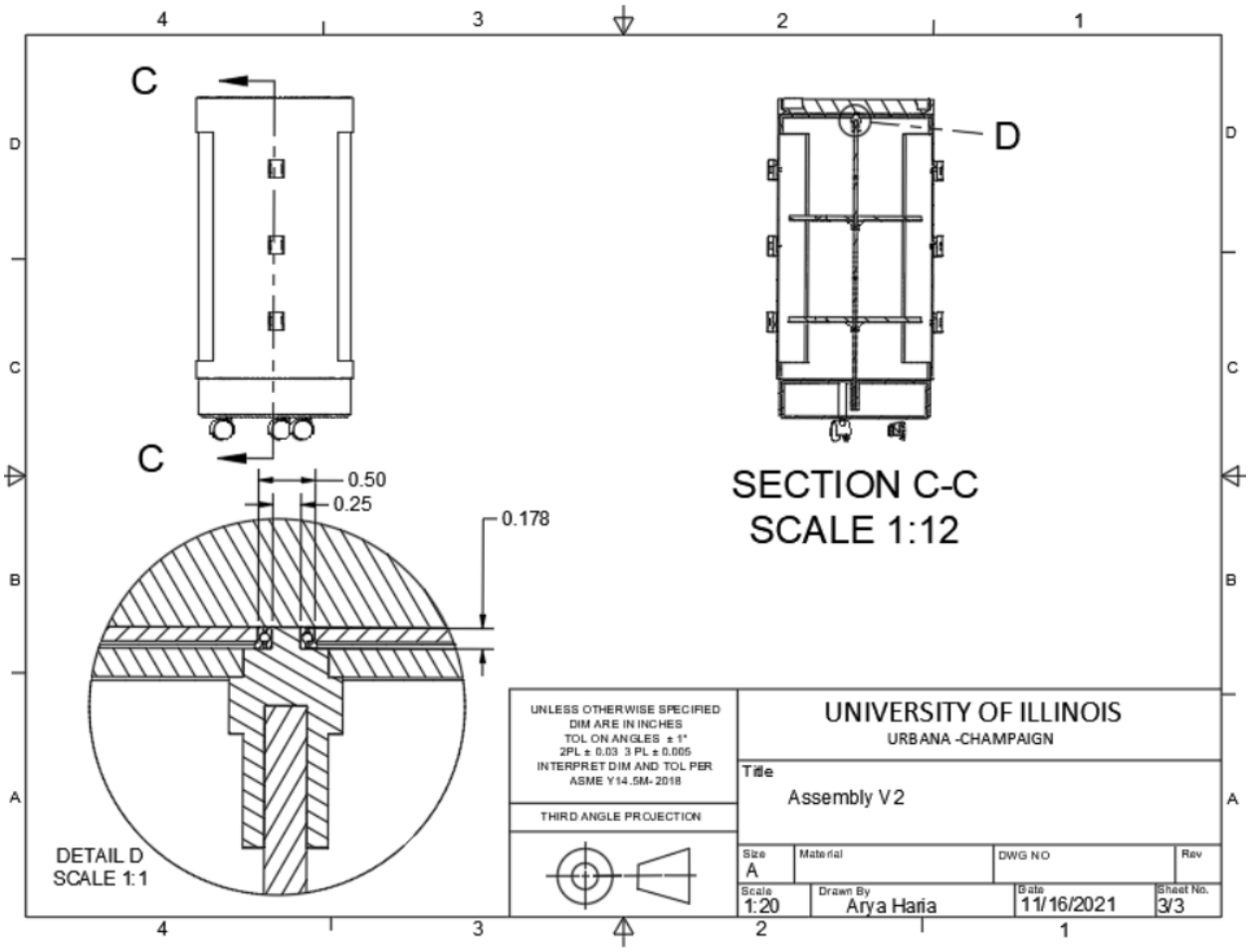
Title
Assembly V2

Size	Material	DWG NO	Rev
A			

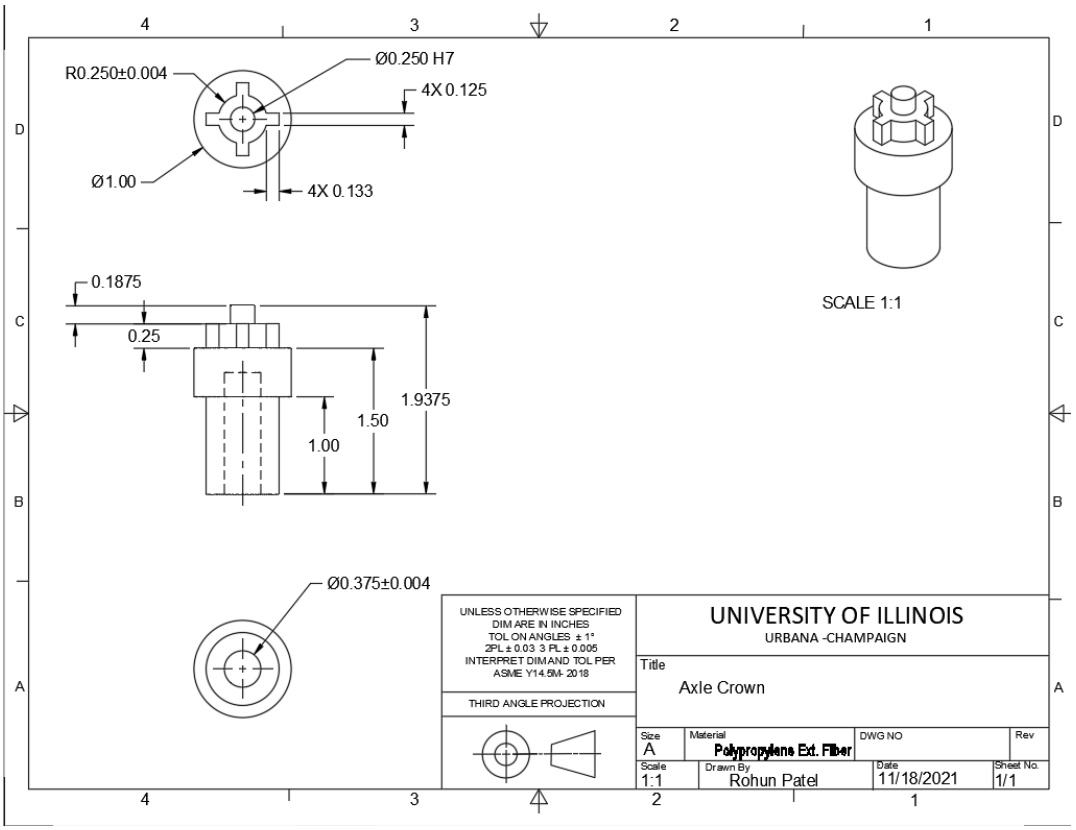
Scale	Drawn By	Date	Sheet No.
1:20	Arya Haria	11/16/2021	1/3

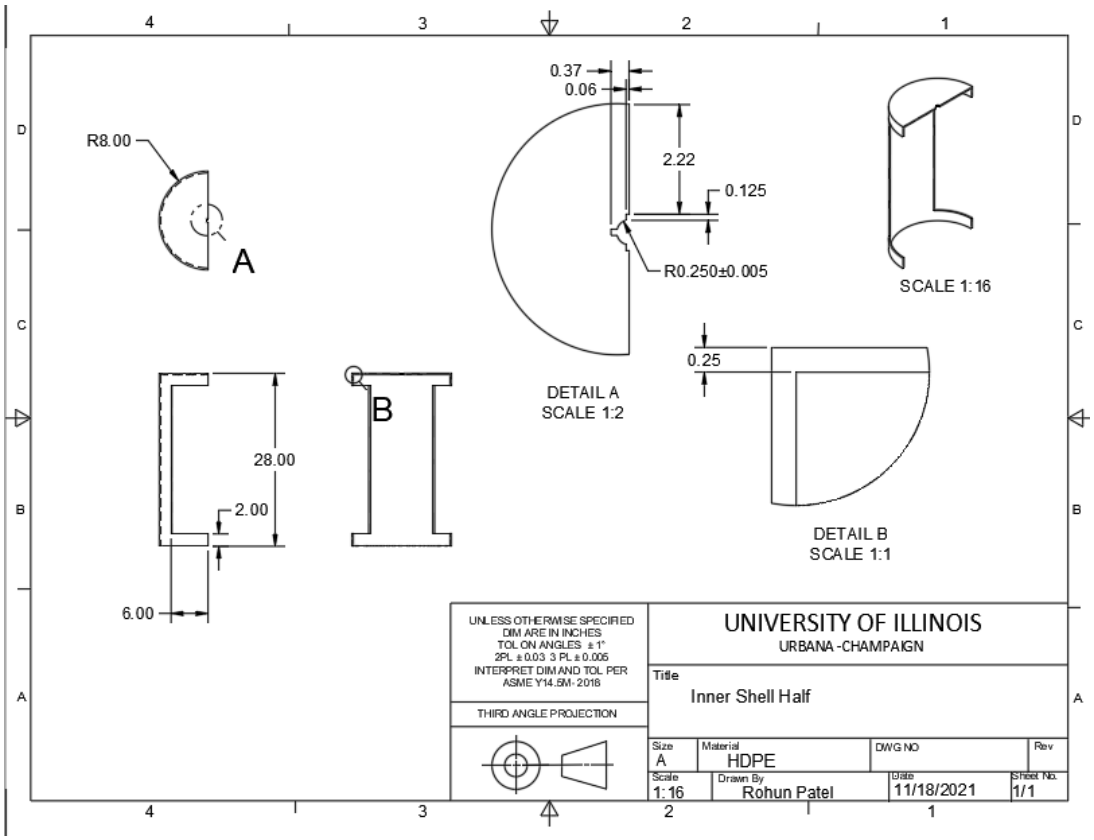
Assembly Drawing With Cross Section:

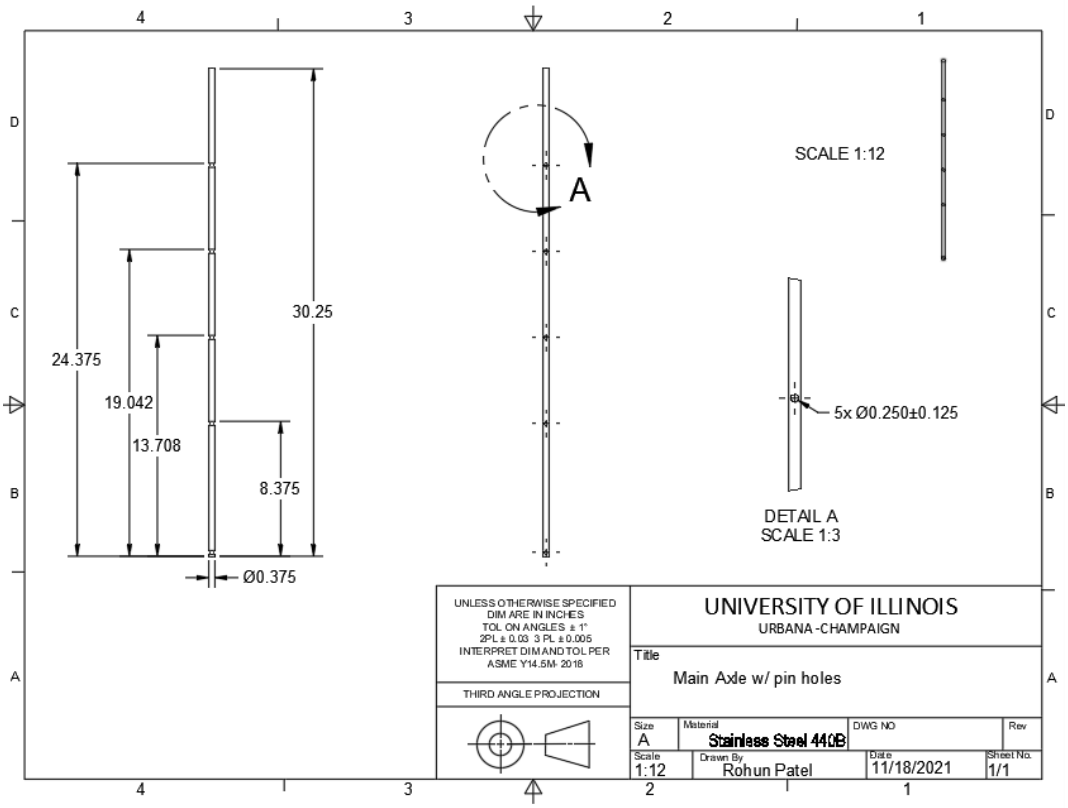


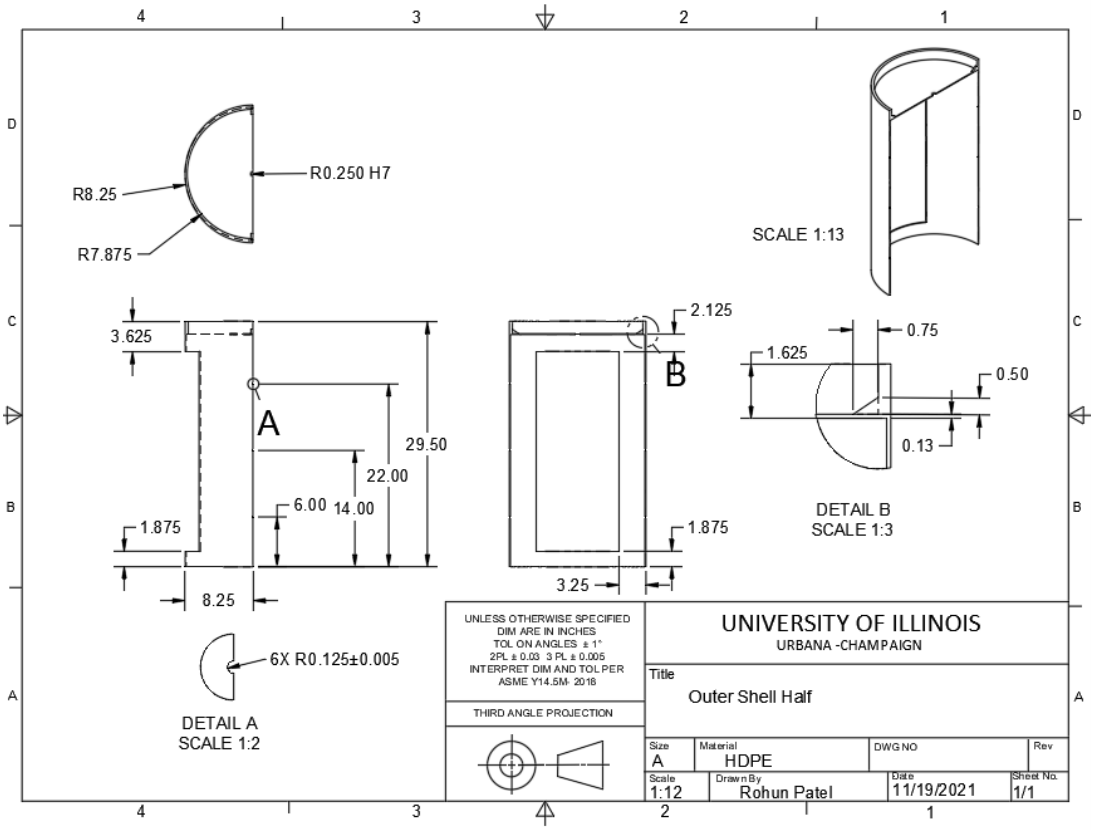

C
C
D
0.50
0.25
0.178
SECTION C-C
SCALE 1:12
DETAIL D
SCALE 1:1
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Assembly V2
Size
A
Material
DWG NO
Rev
Scale
1:20
Drawn By
Arya Haria
Date
11/16/2021
Sheet No.
3/3

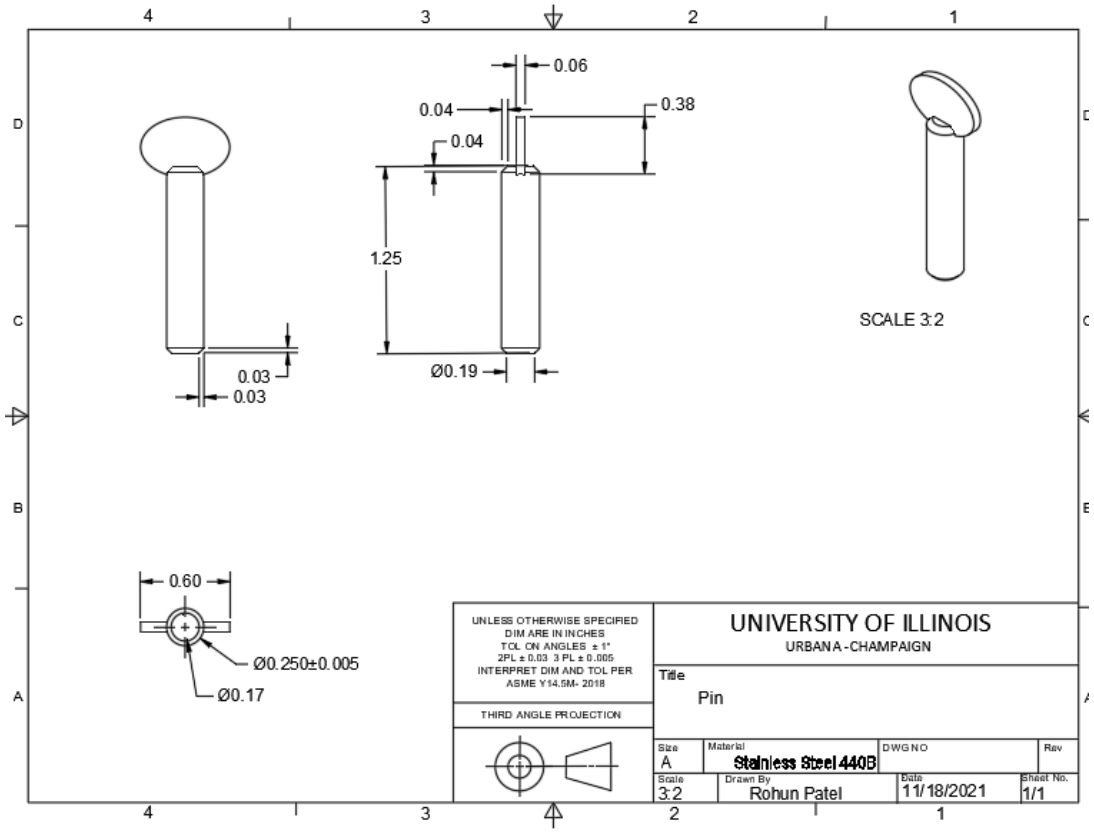
Detailed Engineering Drawings:

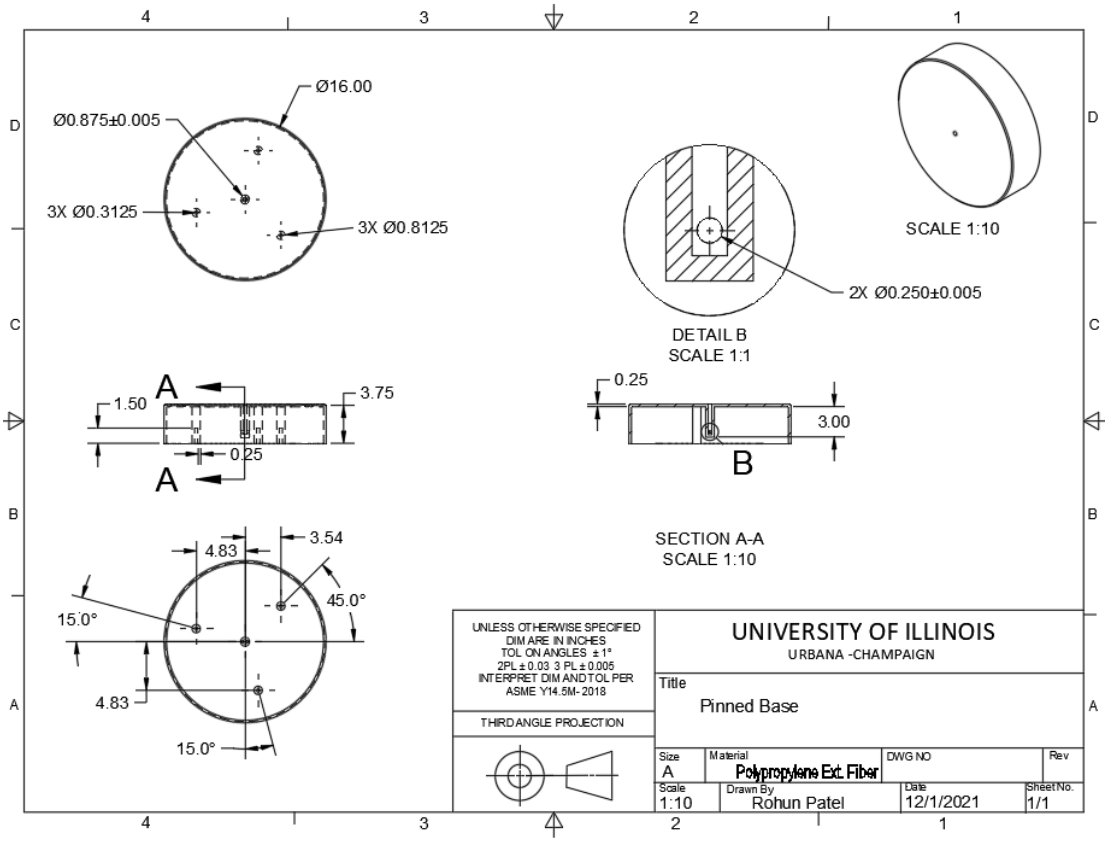


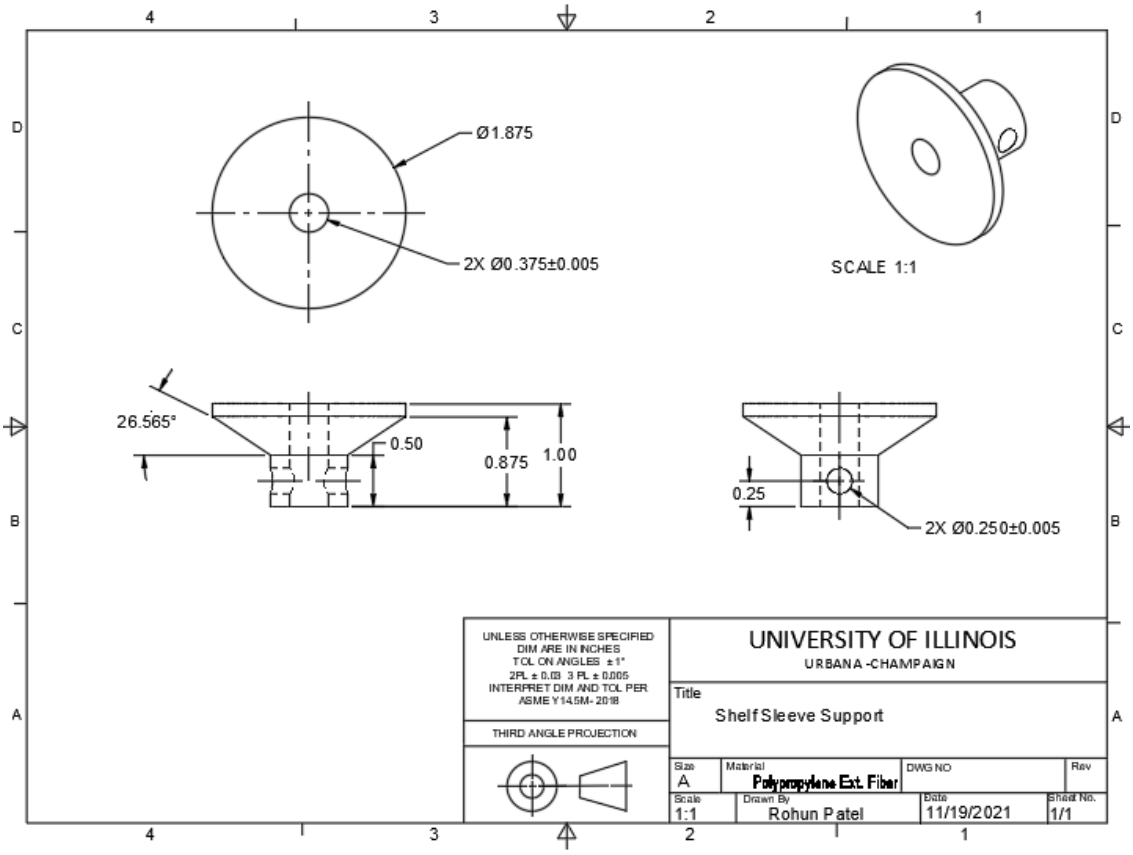


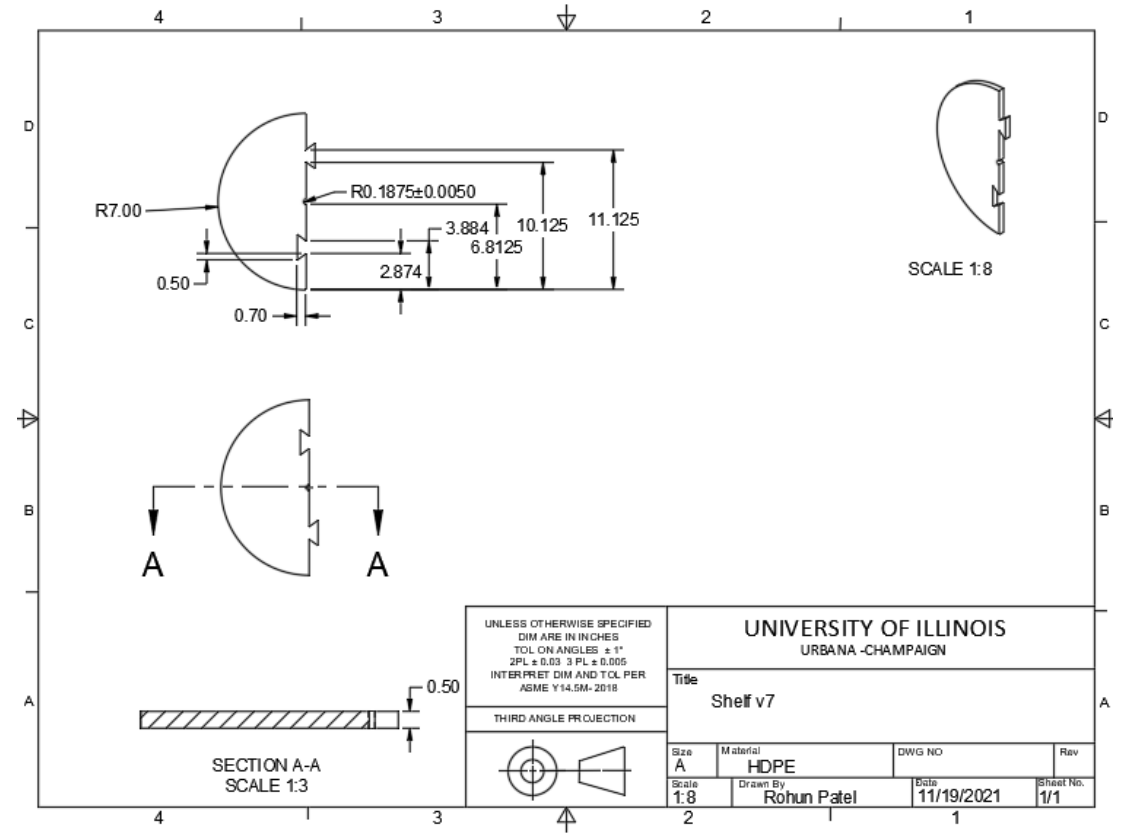

30.25
24.375
19.042
13.708
8.375
Ø0.375
A
SCALE 1:12
5x Ø0.250±0.125
DETAIL A
SCALE 1:3
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Main Axle w/ pin holes
Size
A
Material
Stainless Steel 440B
DWG NO
Rev
Scale
1:12
Drawn By
Rohun Patel
Date
11/18/2021
Sheet No.
1/1

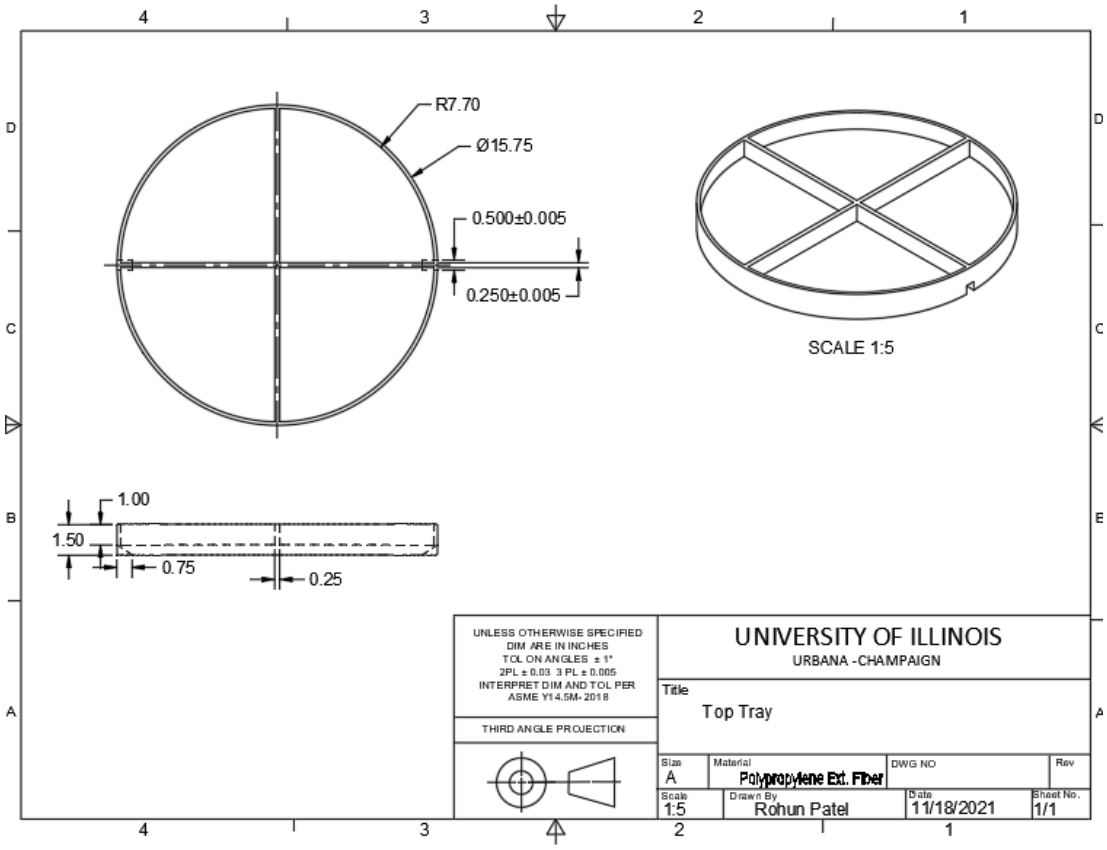

R8.25
R0.250 H7
R7.875
SCALE 1:13
3.625
A
29.50
22.00
6.00
14.00
1.875
8.25
2.125
B
1.875
3.25
0.75
1.625
0.50
0.13
DETAIL B
SCALE 1:3
6X R0.125±0.005
DETAIL A
SCALE 1:2
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Outer Shell Half
Size
A
Material
HDPE
DWG NO
Rev
Scale
1:12
Drawn By
Rohun Patel
Date
11/19/2021
Sheet No.
1/1

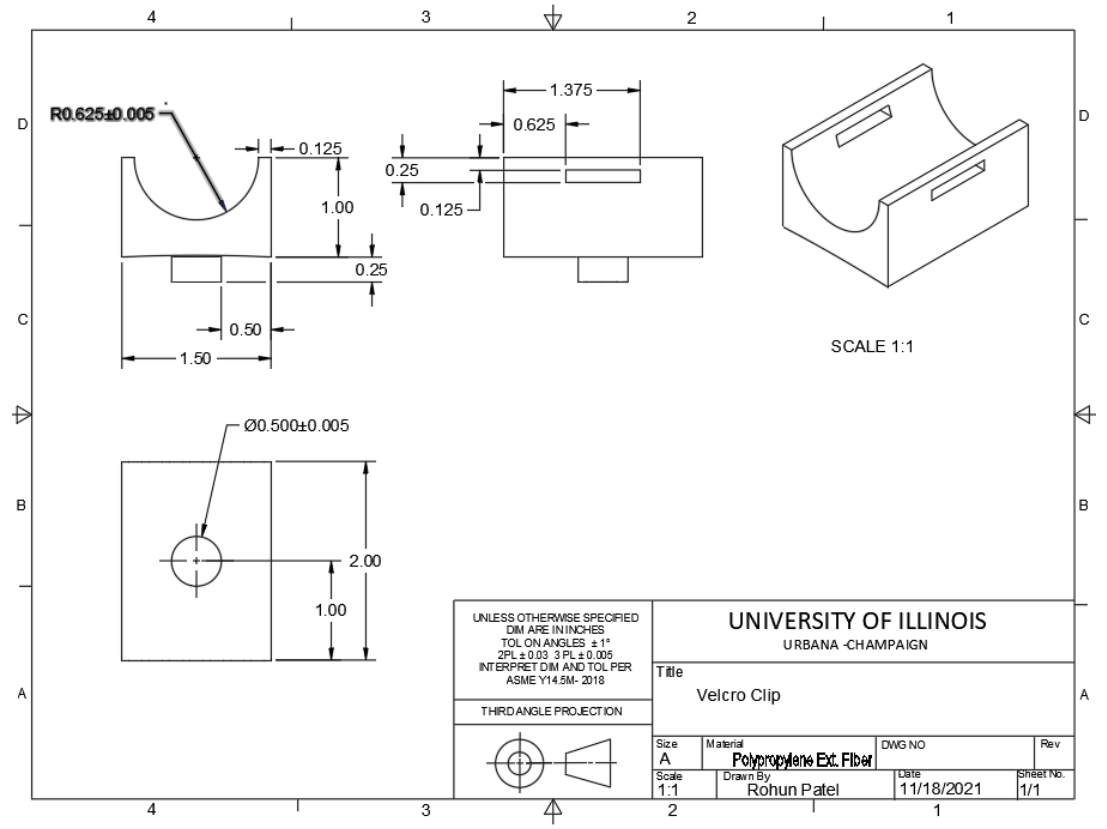

0.06
0.04
0.38
0.04
1.25
0.03
0.03
Ø0.19
SCALE 3:2
0.60
Ø0.250±0.005
Ø0.17
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Pin
Size
A
Material
Stainless Steel 440B
DWG NO
Rev
Scale
3:2
Drawn By
Rohun Patel
Date
11/18/2021
Sheet No.
1/1

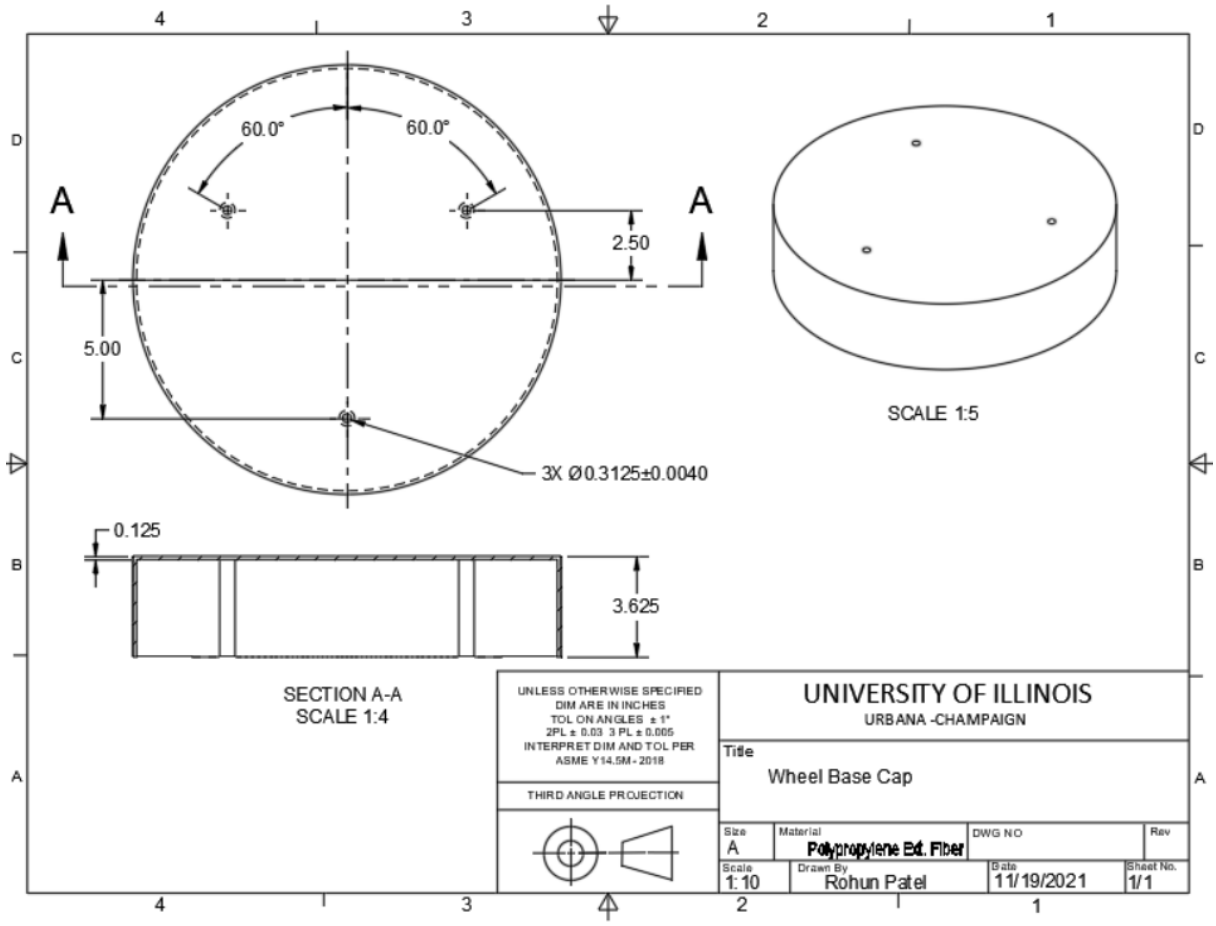

Ø16.00
Ø0.875±0.005
3X Ø0.3125
3X Ø0.8125
SCALE 1:10
2X Ø0.250±0.005
DETAIL B
SCALE 1:1
A
1.50
3.75
0.25
A
0.25
3.00
B
SECTION A-A
SCALE 1:10
4.83
3.54
45.0°
15.0°
4.83
15.0°
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Pinned Base
Size
A
Material
Polypropylene Ext. Fiber
DWG NO
Rev
Scale
1:10
Drawn By
Rohun Patel
Date
12/1/2021
Sheet No.
1/1


Ø1.875
2X Ø0.375±0.005
SCALE 1:1
26.565°
0.50
0.875
1.00
0.25
2X Ø0.250±0.005
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Shelf Sleeve Support
Size
A
Material
Polypropylene Ext. Fiber
DWG NO
Rev
Scale
1:1
Drawn By
Rohun Patel
Date
11/19/2021
Sheet No.
1/1


R7.00
R0.1875±0.0050
3.884
10.125
11.125
6.8125
2.874
0.50
0.70
SCALE 1:8
A
A
0.50
SECTION A-A
SCALE 1:3
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Shelf v7
Size
A
Material
HDPE
DWG NO
Rev
Scale
1:8
Drawn By
Rohun Patel
Date
11/19/2021
Sheet No.
1/1


R7.70
Ø15.75
0.500±0.005
0.250±0.005
SCALE 1:5
1.00
1.50
0.75
0.25
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Top Tray
Size
A
Material
Polypropylene Ext. Fiber
DWG NO
Rev
Scale
1:5
Drawn By
Rohun Patel
Date
11/18/2021
Sheet No.
1/1


R0.625±0.005
0.125
1.00
0.25
0.50
1.50
1.375
0.625
0.25
0.125
SCALE 1:1
Ø0.500±0.005
2.00
1.00
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M- 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Velcro Clip
Size
A
Material
Polypropylene Ext. Fiber
DWG NO
Rev
Scale
1:1
Drawn By
Rohun Patel
Date
11/18/2021
Sheet No.
1/1


60.0°
60.0°
A
A
2.50
5.00
3X Ø0.3125±0.0040
0.125
3.625
SECTION A-A
SCALE 1:4
SCALE 1:5
UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLES ± 1°
2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
ASME Y14.5M - 2018
THIRD ANGLE PROJECTION
UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
Wheel Base Cap
Size
A
Material
Polypropylene Ext. Fiber
DWG NO
Rev
Scale
1:10
Drawn By
Rohun Patel
Date
11/19/2021
Sheet No.
1/1

Tolerance Analysis:

Shaft diameter : ¼" : G7/h6

Outer shell half and shaft: Sliding H7/g6 6.35 mm

Radial Fits:

Bearing ID w/ Axle Crown

Allowance = 6.35 - 6.345 = 0.005 mm

Clearance = 6.365 - 6.336 = 0.029 mm

Bearing OD w/Outer Shell Halves

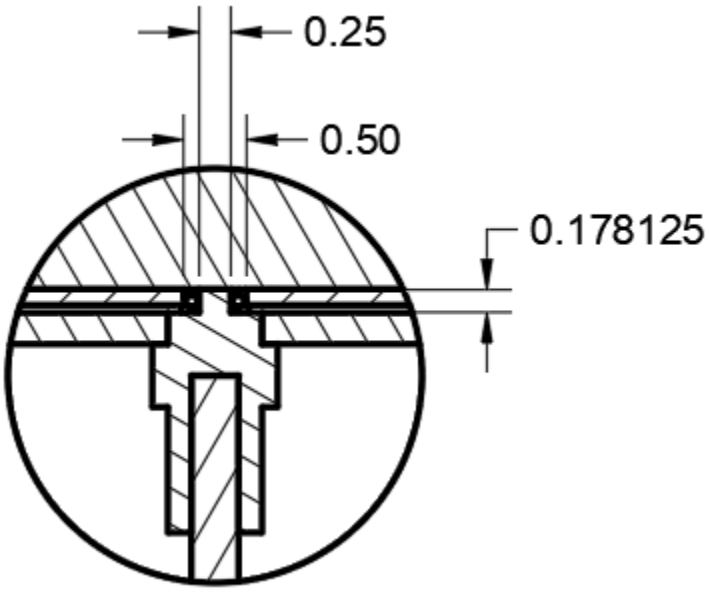
Allowance = 12.7 - 12.694 = 0.006 mm

Clearance = 12.718 - 12.683 = 0.035 mm

Axial Fits:

Allowance = 4.7625 - 4.7585 = .004 mm

Clearance = 4.7745 - 4.7505 = .024 mm



Materials and Manufacturability:

Part #	Description	Material and Manufacturing Method (or order details if an off-the-shelf item)	Part Cost (fully burdened and catalog)	Quantity	Total Part Costs	Investment Costs (tooling, fixtures etc)
Part 1	Axle Crown	Injection Molding (PP Ext. Fiber)	2.13	1	2.13	9698.53
Part 2	Bolt	McMaster Carr - catalog ID : 91794A583	0.56	3	1.68	0
Part 3	Flanged Bearing	McMaster Carr - catalog ID : 57155K323	6.12	1	6.12	0
Part 4	Inner Shell Half	Sheet Plastic : 4 Cavities Drape Forming (HDPE)	12.59	2	25.18	26,391.11
Part 5	Main Axle	Stock Machining (Stainless Steel 440B)	5.96	1	5.96	853.87
Part 6	Outer Shell Half	Sheet Plastic : 2 Cavities Drape Forming (HDPE)	9.58	2	19.16	22,358.75
Part 7	Pin	Waterjet Cut (Stainless Steel 440B)	0.12	3	0.36	0
Part 8	Pinned Base	Injection Molding (PP Ext. Fiber)	24.8	1	24.8	35190.27
Part 9	Screw Cap	McMaster Carr - catalog ID : 91620A110	0.22	3	0.66	0
Part 10	Shelf Sleeve Support	Injection Molding (PP Ext. Fiber)	2.49	2	4.98	18,285.46
Part 11	Shelf	4 Cavities Drape Forming (HDPE)	13.22	4	52.88	8088.14
Part 12	Top Tray	Injection Molding (PP Ext. Fiber)	26.34	1	26.34	28,456.55
Part 13	Velcro Clip	Injection Molding (PP Ext. Fiber)	1.73	6	10.38	18,997.19
Part 14	Wheel	McMaster Carr - catalog ID : 24215T67	2.6	3	7.8	0
Part 15	Wheel Base Cap	Injection Molding (PP Ext. Fiber)	7.9	1	7.9	31779.81
				TOTAL	196.33	200099.68
		Volume - 1,000,000 in batch sizes of 5.00 yrs'				

Conclusion:

Going forward, our first step before bringing the product to the mass market would be lowering the manufacturing cost. Although we were able to lower tooling costs by incorporating off-the-shelf items, the total cost is still far too high for us to begin production. We'd recommend looking into the root of the high cost (part design, material, manufacturing method, etc.) and addressing it accordingly in order to bring costs down. If costs continue to be high, then we would recommend changing the target demographic of the product towards adults living in condominiums and apartments rather than students living in dorms, making the product a more luxurious item directed towards people of a higher income and/or budget. At its current price point, we would consider the product to be a risky investment. Without promising evidence of consumers willing to pay a higher price for the product, our margins for profit are very minimal. Even as a luxury item, we wouldn't expect to price the product at more than $100-150, meaning that our manufacturing cost should be closer to $35-40. With the current figures in mind, it would not be smart to move forward with our product unless major changes were made and the cost of manufacturing decreased dramatically. Considering the manufacturing design experience that our group lacks, it was definitely a challenge working with and designing our product. We combined fifteen different parts of varying shapes and sizes to make a compact and customizable storage system. Although the product may look simple on the outside, there were many aspects of it to consider when designing certain parts. Our shelves, for example, required a dove-tail connection in order to be easily removed/adjusted while also being strong and supportive for any products on top of it. Due to the restrictive nature of the walls of the container, we needed the connection to separate vertically as opposed to horizontally as well as we needed a supportive slider on the underside to help reinforce. We also had to get creative with our door mechanism

,centralto since the product was intended to sit in the corner of the room. We decided to use a rotary-type door in order to avoid having the doors hit the walls when being opened and in doing so allow for the product to be tucked even deeper into the corner of the room. Unlike most groups, we went with a fairly large product, making our manufacturing method much more complicated. We did our best to keep this in mind as we struggled with high manufacturing and tooling costs, even though we were still left with an expensive product. In the end, we did our best to challenge ourselves and are proud of the final product we were able to present. We were able to learn a lot from designing the product as well as gain valuable experience in manufacturing design.