EZ-Boiler

Quick Food Boiler

ME 170 Design Team
AB6-11

Team Members:
Andrew Park
Jose Gonzalez
Jackson Delia
Andy Zhang

Date: 12/04/2023

Product Description:

All inventions have a purpose - to fulfill an unmet need. For this project, we were tasked with creating a mechanical or electromechanical device to fulfill an unmet need in our society using the human-centered design (HCD) process. In order to begin searching for unmet needs in our society, our group began by interviewing each member of the team using the following questions: 1) Is there a product that makes your day easier? 2) What electro-mechanical product could you not live without? 3) What's the biggest inconvenience in daily life?

Throughout the interview process it was found that the simplest electro-mechanical device that was essential to one of our group members' convenience was an air fryer. All other answers consisted of complex electronics that were beyond the scope of what we were able to create. Working with the concept of air fryers, we began to brainstorm possible upgrades to the air fryer, which was the driving force behind our next set of interviews.

These following interviews were people picked from the general population who owned air fryers. The questions included mostly general questions relating to food preparation with one question specifically regarding the interviewee's least favorite thing about their air fryer. Despite interviewing three people, we were not able to find common ground about the downsides of air fryers, and it actually seemed as though the air fryer had little to no problems, and that everybody who owned one was very happy with it. This didn't mean, however, that we did not gather useful information from these interviews. One interesting takeaway was that every single person interviewed expressed a deep hatred for boiling food.

Working off of this information, we compiled the reasons people hated boiling, which all really boiled down to a simple lack of convenience. When boiling food, one must fill a pot with water, place it on the stovetop and watch until the water begins to boil. They then must add the desired food and watch constantly to make sure the water doesn't overflow and cause a mess. This entire process can take an hour or more, and all of it requires constant oversight and focus. The tediousness of this process was a massive turn away from boiling food, leading people away from foods like pasta, ramen, and boiled vegetables.

While it wasn't in the area we originally speculated, our group had finally found our unmet need: the inconvenience of boiled food. This led to the creation of our driving question: How might we make the food preparation process for boiled foods require less user input and effort? In response, we decided on an easy-boil machine that required 3 inputs - water, food, and a digital time input - and would output fully boiled food at the end of the specified time. This appliance would be relatively portable, and would be able to contain multiple types of boiled food, including noodles, pasta, potatoes, eggs, and various vegetables. The entire point of this appliance is to reduce the amount of effort required to boil food. The user would input the water, food, and time, and then have time to do other things while the boiling process was fully automated. Surprisingly, there exists nothing quite like this product for a home use setting. The closest things that do exist are electric kettles, which are too small or awkwardly shaped to contain food, and deep-fryers, which do not boil food, but instead use oil to fry it. Our design would end up being more or less a combination of the electric kettle and deep fryer to create an easy and efficient food boiling device.

Concept Sketches:

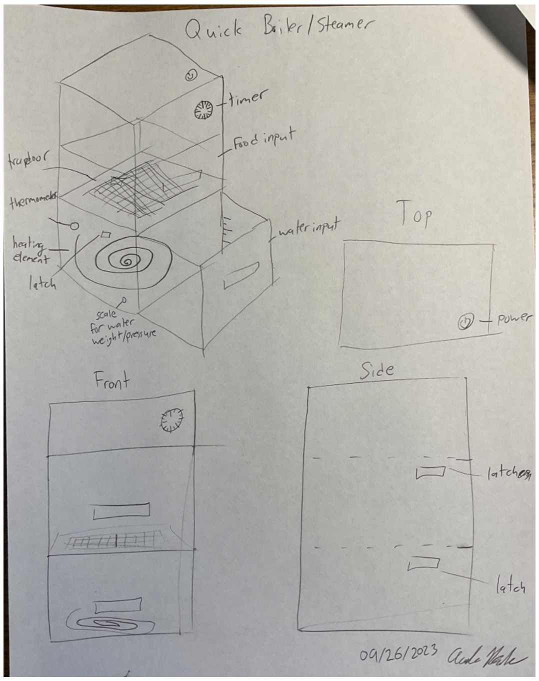


Figure 1 (Andrew Park)

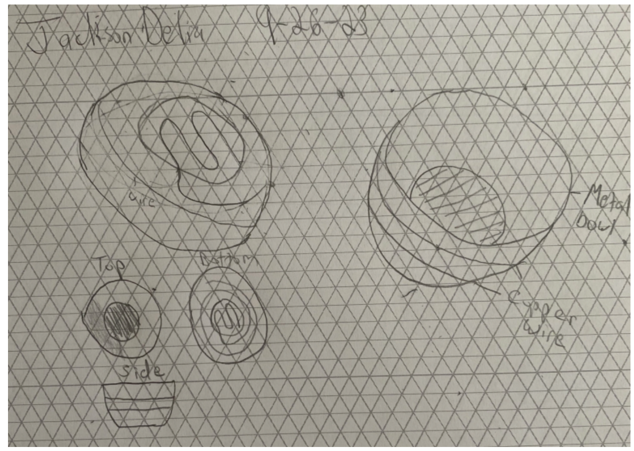


Figure 2 (Jackson Delia)

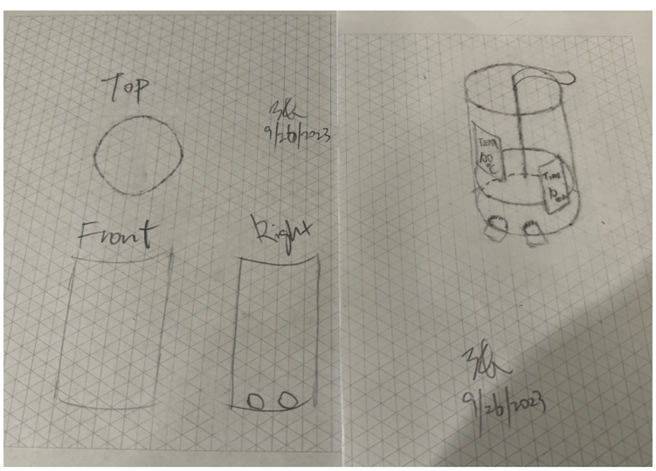


Figure 3 (Andy Zhang)

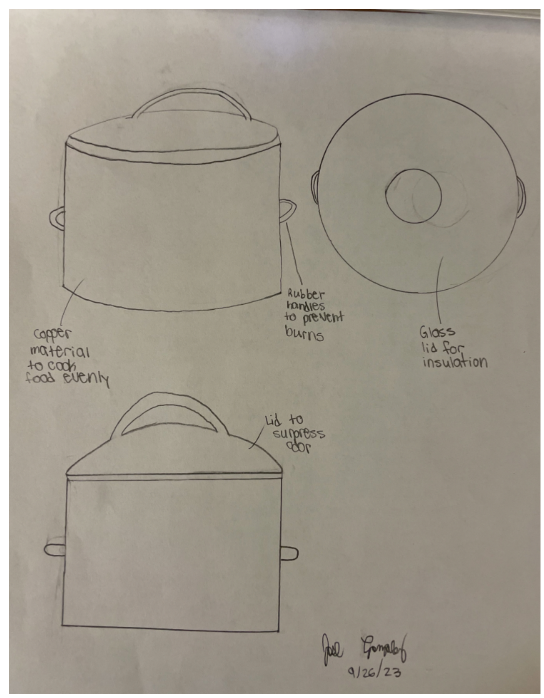


Figure 4 (Jose Gonzalez)

For the design process, each member was tasked with sketching his own concept of how the product would look and function. These are shown above, and were also used in the Pugh selection process (the specifications and decision process will be detailed in the following section). Eventually, our team would decide to use Figure 3 as the basis for our design because it scored the highest in the matrix.

Concept Selection Process:

Figure #	5	1	2	3	4
Performance		+	-	+	+
Environment		S	-	S	-
Maintenance	D	-	+	S	+
Target costs	A	-	+	+	+
Product volume	T	S	-	S	+
Size	U	+	+	S	-
Materials	M	-	+	-	+
Product life span		-	-	+	+
Quality and reliability		+	-	+	+
Safety		+	-	-	+
TOTALS:		4+ 4-	4+ 6-	4+ 2-	8+ 2-

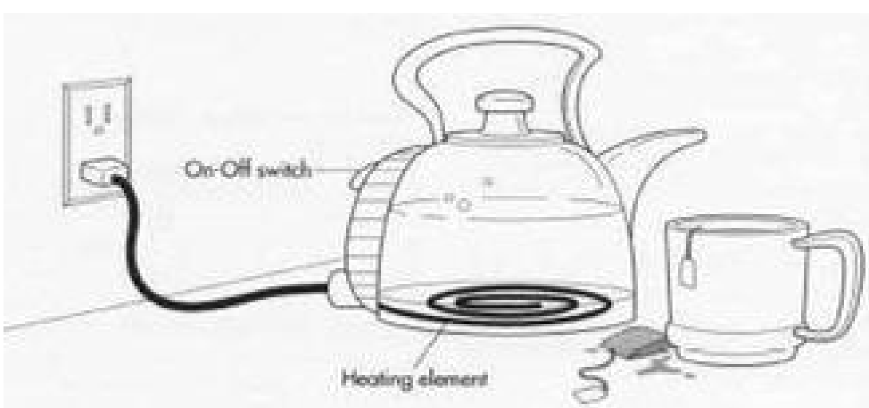


Figure 5

Figure 5 illustrates the basic design of the current competition for our product: a basic electric kettle. This design was chosen as our datum because ideally, this is what we are going to be competing with on the market, so our product should be more efficient and convenient than this design.

Figure 1 depicts a two-compartment device with one compartment available for water and the other for any desired steamed food. This was not chosen because of the many inconveniences associated with the lack of a food container for boiled food. In other words, there is no way to extract the boiled food from the water at the end.

Figures 2 and 4 are similar to each other in that they are both bowls with heating elements at the bottom. The user would put the food and water into the bowls and they would boil together with a lid on top until finished. Again, there exists no way to extract the food from the water upon completion, other than to flip the entire device upside down, spilling water and food everywhere.

Finally, figure 3 is a 2-layered container with a mesh-like food container (not shown, but was later described) that is hidden by the outer wall in the drawing, but is implied through the handle sticking out of the top of the device. This basket provides a way for the user to remove the food from the water without needing to flip the entire device. The design also incorporates a touchscreen control panel as well as an inlet and outlet for water, both of which we decided against using for complexity reasons.

After tallying up the various pros and cons of each design, it was clear that figure 3 was the best choice.

Product Design Specification:

1. Performance
    a. To satisfy user convenience aspects, the minimum time required to fully prepare food should be around 5 min. To be considered realistic, however, there should also be a maximum time of around 45 minutes (depending on the input).
    b. Power will run when the device is turned on, and heating/boiling will run continuously once the timer is set
    c. The device will require electrical loadings, specifically for heating elements, a power switch, a timer, a pressure sensor, and a thermometer (possibly)
    d. In order to run at full efficiency, lots of electrical data and more complex circuitry would be required. Unfortunately, we don't know how to design such circuitry at the moment, so the accuracy will most likely not be very precise. That being said, the processes done on the device will be consistent, so results will vary based on variation in user input (i.e. time, amount of water, food type and quantity)
2. Environment
    a. Due to the heating elements present in the device, it will need to withstand heats of up to 150 degrees Celsius (not likely to go much over 100)
    b. The boiling pot/section as well as food input need to be easily accessible for cleaning, as constant use will create unwanted food and waste buildup
    c. Needs to be able to withstand corrosion from water and cleaning elements
    d. Keep out of reach of little children, as electrocution is possible
3. Service Life
    a. Service life should be relatively long, (equivalent to that of other food-prep appliances) which is about five to eight years
4. Maintenance
    a. The appliance would ideally be as low-maintenance as possible, but seeing as how it is dealing with food, would require a certain level of maintenance regardless
    b. Ideally, the appliance would not require any specific cleaning supplies (other than non-toxic kitchen/dish washing supplies)
    c. Once again, parts should be easily accessible and removable to facilitate easy cleaning
5. Target Costs
    a. Target price should not be over $150 to keep it affordable and widely available, but not below $50. Ideally, the price would hover closer to $75 per appliance.
    b. It's important to note that demand for this product is unknown as there is currently no existing competition, meaning no price or demand comparison
6. Competition
    a. There is no convenient easy-boil kitchen appliance currently in mass distribution

    b. This could be due to lack of demand, or because it’s genuinely a new idea
7. Shipping
    a. Shipping by truck to retailers would work just fine. The appliance is not fragile, and should be able to withstand minor bumps and jostling.
    b. International shipping can be done via plane or boat (it’s cheaper to manufacture outside of the U.S.)
    c. Shipping would be done in bulk in pallet containers, not individually,
8. Product Volume (Quantity)
    a. The product would likely be cylindrical-like (vertical) shaped more or less like a rice-cooker
    b. It may be a bit larger than a rice cooker/air fryer so as to actually have enough space to fit food
    c. Overall, dimensions of about 1.5ftx1.5ftx2ft would be the maximum surrounding rectangle. Unfortunately, this is relatively large, but would be able to store more food
    d. As far as manufacturing goes, normal sheet metal would work for most components, but the outside would be a plastic injection mold
9. Packing
    a. Packing needs to prevent any fragile parts on the outside from getting damaged.
    b. Bubble wrap in a box no more than 10mm bigger than the product in each direction would prevent damage.
10. Manufacturing Facility
    a. No new facilities would be created for this product, any sheet metal fabrication facility should do. Will also need CNC bending capabilities for copper wire.
11. Size
    a. A maximum size of 450mm x 450mm x 600m would provide a sizable bowl for boiling water.
    b. A minimum size of 165mm x 165mm x 65mm for the bowl, ± 5mm for a conduct wire around the outside in order to heat the bowl.
    c. Optimum size of 200mm x 200mm x 110mm so the bowl could comfortably hold at least half a gallon of water without the water boiling over.
12. Weight
    a. Provided portability isn’t a huge factor for this, a minimum of 12 lb to provide for a sturdy bowl that won’t warp due to heat.
    b. A maximum of 20 lb, since a bowl too thick will take longer to transfer the heat into the water.
13. Aesthetics and Finish
    a. Keeping an outside finish to keep the unsightly copper wire from view would be ideal.
14. Materials

    a. Since the product will boil water to make food, it should not contain any materials that may release toxic chemicals under heat.
    b. Stainless steel would be the material of choice for the bowl, with copper wire running around the outside of the bowl.
    c. Plastic molds should be kept away from the copper.
15. Product Life Span
    a. Product would remain in production for 5 years.
16. Standards, Specifications, and Legal Aspects
    a. Our product will follow minimum food protection and sanitation requirements for the materials, design, construction and performance of commercial cooking.
17. Ergonomics
    a. Product will sit on the top of a stove at a height convenient to the consumer.
    b. The device will have rubber handles to prevent consumers from burning their hands.
18. Customer
    a. A major concern consumers have with boiling appliances is the amount of time it takes to prepare food. Our device will aim to resolve this problem by preparing food in around 5 min.
    b. Another problem customers may have is burning themselves when trying to hold boiling appliances, which we will resolve with rubber handles.
19. Quality and Reliability
    a. Mean time between failure will be around 5-7 years per unit
    b. Product will aim within +-6 DPU
20. Shelf Life
    a. Consumers can expect this appliance to last anywhere from 5-7 years. After this period, the product will start to peel and cook improperly, even contaminating food.
21. Processes
    a. Our product will be manufactured using a casting process that begins with melting and holding equipment. The steel used for our appliance will be melted down and then poured into a cast. The casts are then cooled, possibly requiring heat processing in a furnace to achieve the desired hardness.
22. Timescales
    a. Taking into account the time required to design, prototype, test and manufacture the appliance, our final product is projected to be finished by Dec 8th.
23. Testing
    a. Test that water does not leak while boiling
    b. Test that water does get to 100 degree celsius
    c. Test that the program cooks the food thoroughly
24. Safety

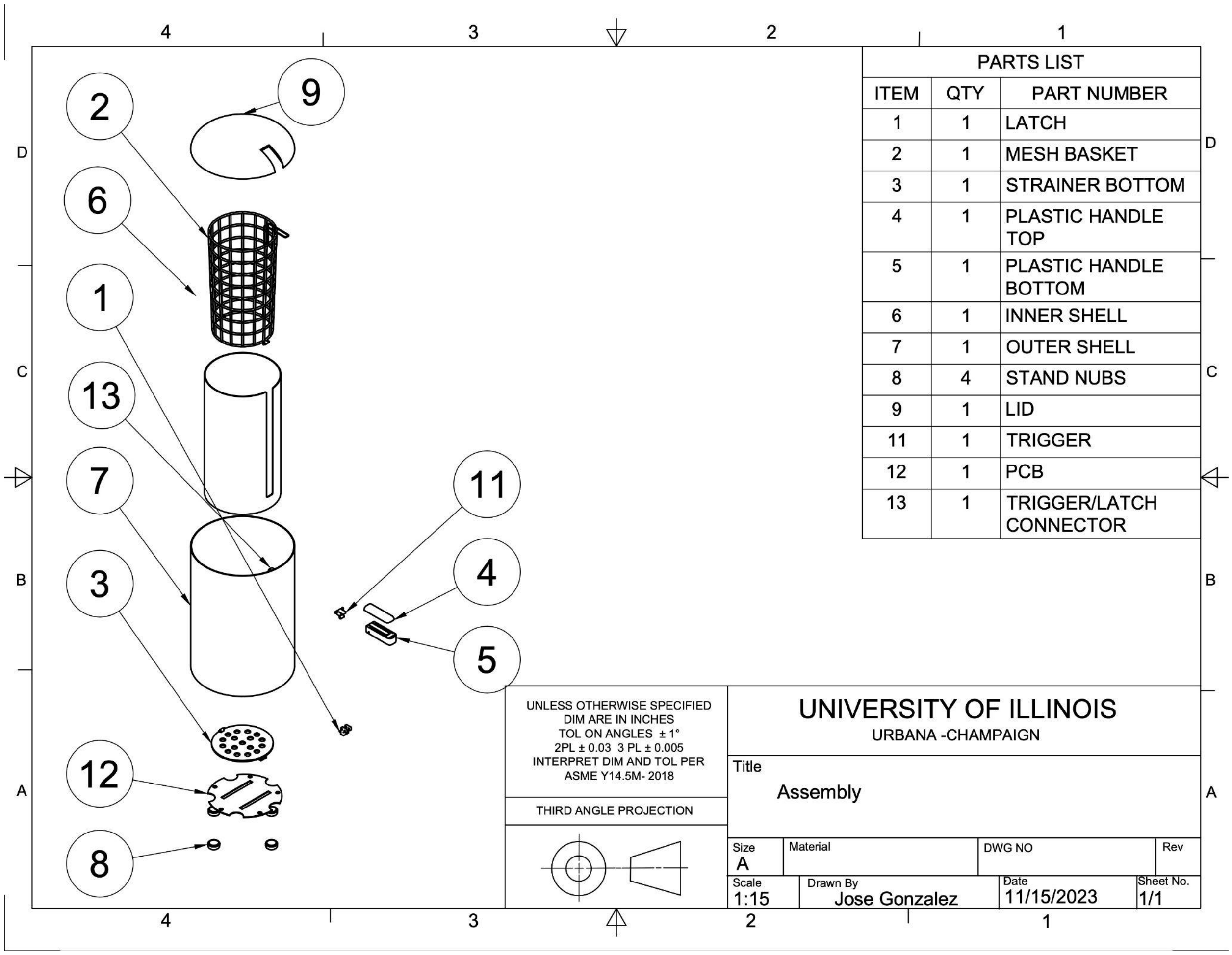
    a. Make sure no electric leakage happens
    b. Safety measure to cut off power if electric leakage does happen
25. Company Constraints
    a. Make sure that it does not conflict with existing products
26. Market Constraints
    a. As it is new to the market, it should be open to all customers, regions, countries, etc
27. Patents, Literature, and Product Data
    a. Literature and data on the design of similar products, such as water boilers and heaters, can be reviewed
    b. Patents of relevant products to be researched
28. Political and Social Implications
    a. No political or social implications to be considered
    b. But differences of eating habits in different countries can be considered
29. Disposal
    a. Less plastics and steel being used, less pollution to the environment after disposal

CAD Models:

The image above depicts the unexploded assembly of the EZ-Boiler. Visible in the image are the outer shell, handle, and lid that make up our design.

The image above depicts an exploded view of our EZ- Boiler. Our design consists of (from top to bottom) a lid, mesh basket, inner shell, outer shell, plate, PCB, nubs, latch, trigger and handle. The lid in this design serves to trap heat, allowing food to boil effectively. Together, the metal plate and mesh basket serve as a strainer, allowing water to exit as the consumer retrieves the food they are boiling. The inner shell of this design serves as a conductor of heat, spanning around the whole mesh basket, making for an evenly cooked product. The outer shell of this boiler is an insulating plastic that is available for consumers to touch without risk of burns. The nubs on this design are convenient additions for the boiler to stand on. Lastly, the latch connector in this design serves as a connective mechanism between the trigger and the latch, allowing for consumers to open the latch by the pull of the trigger, placing the food wherever they please without needing to flip the entire basket upside down.

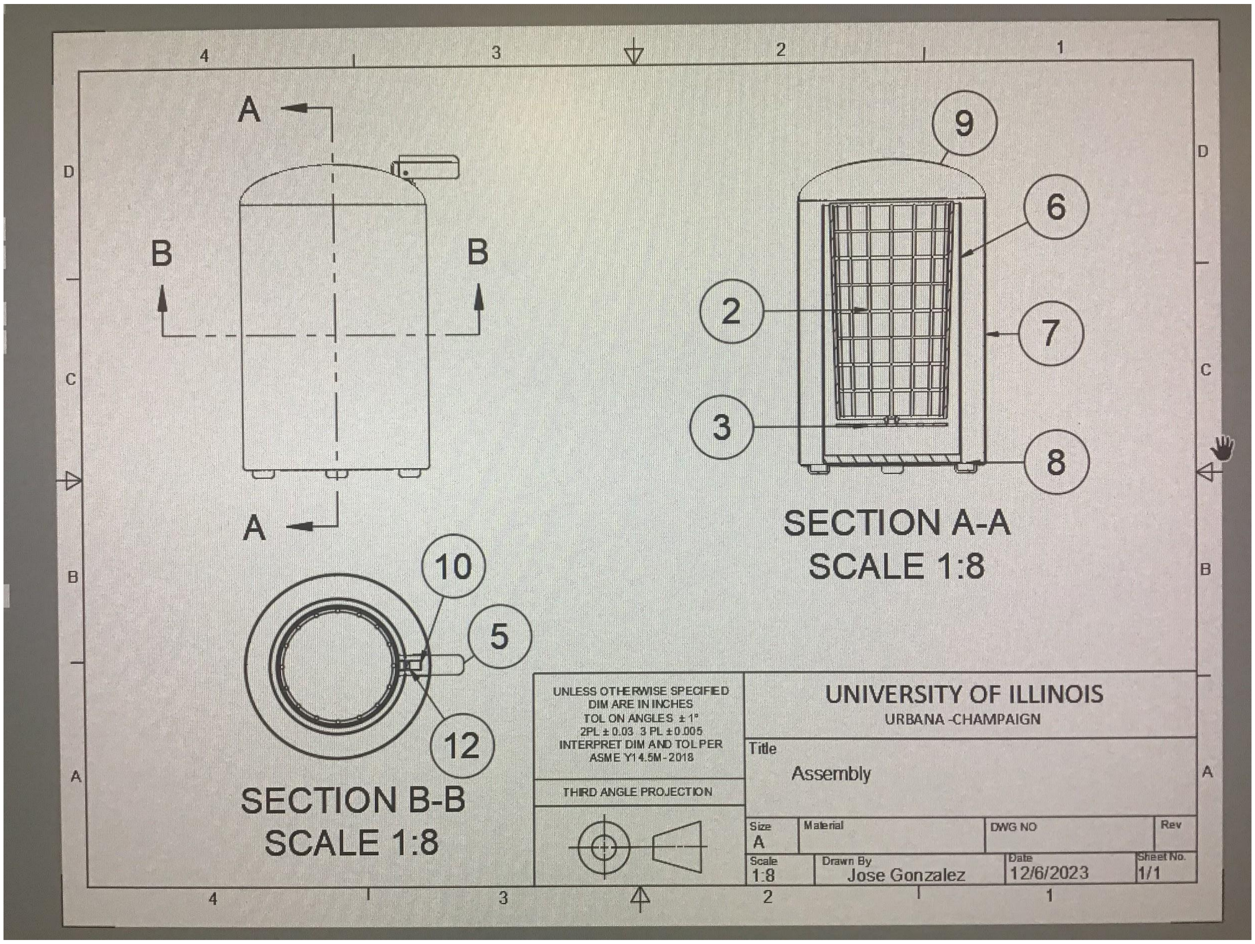
Exploded Assembly Drawing with Bill of Materials:



PARTS LIST

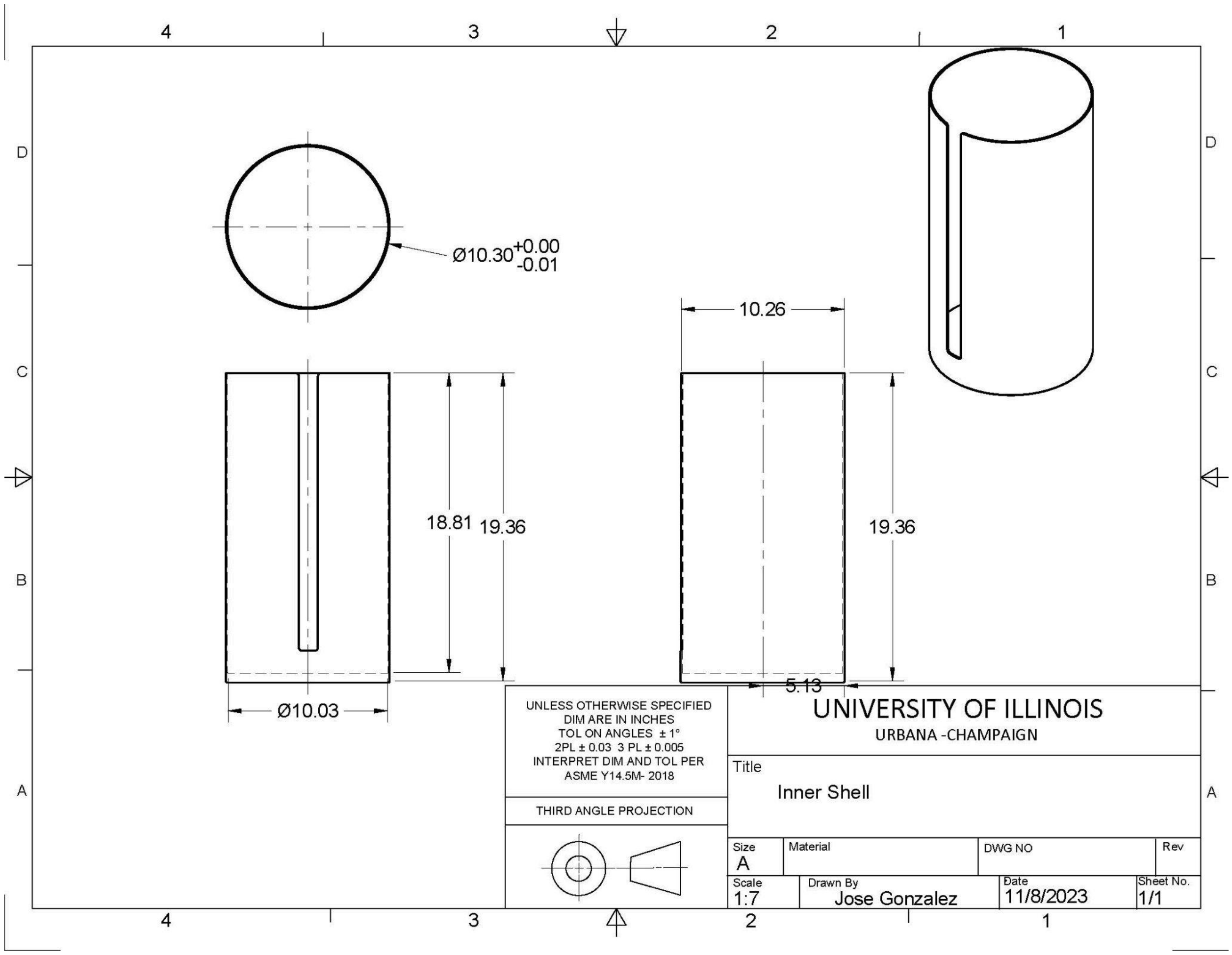
ITEM	QTY	PART NUMBER
1	1	LATCH
2	1	MESH BASKET
3	1	STRAINER BOTTOM
4	1	PLASTIC HANDLE TOP
5	1	PLASTIC HANDLE BOTTOM
6	1	INNER SHELL
7	1	OUTER SHELL
8	4	STAND NUBS
9	1	LID
11	1	TRIGGER
12	1	PCB
13	1	TRIGGER/LATCH CONNECTOR

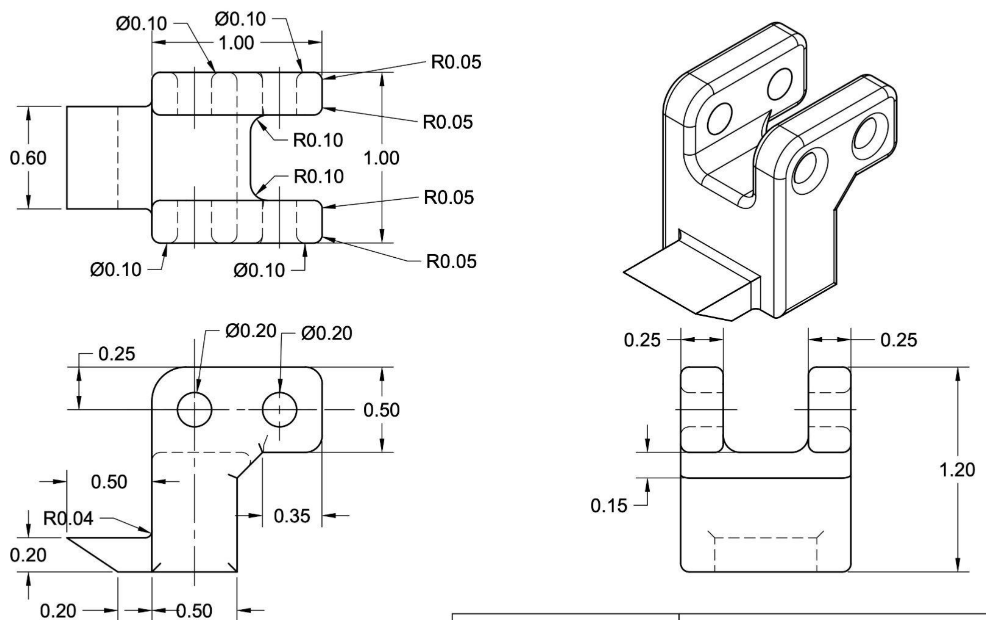
Assembly Drawing with Cross-Sections:



The following image depicts drawings of two cross-sections of our EZ-Boiler. The balloons in these drawings highlight pivotal parts of our design, whose numbers correspond to the item number on our bill of material. These highlighted parts include the mesh basket, metal plate (strainer bottom on BOM), handle, inner shell, outer shell, nubs, trigger, and latch connector.

Detailed Engineering Part Drawings:





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

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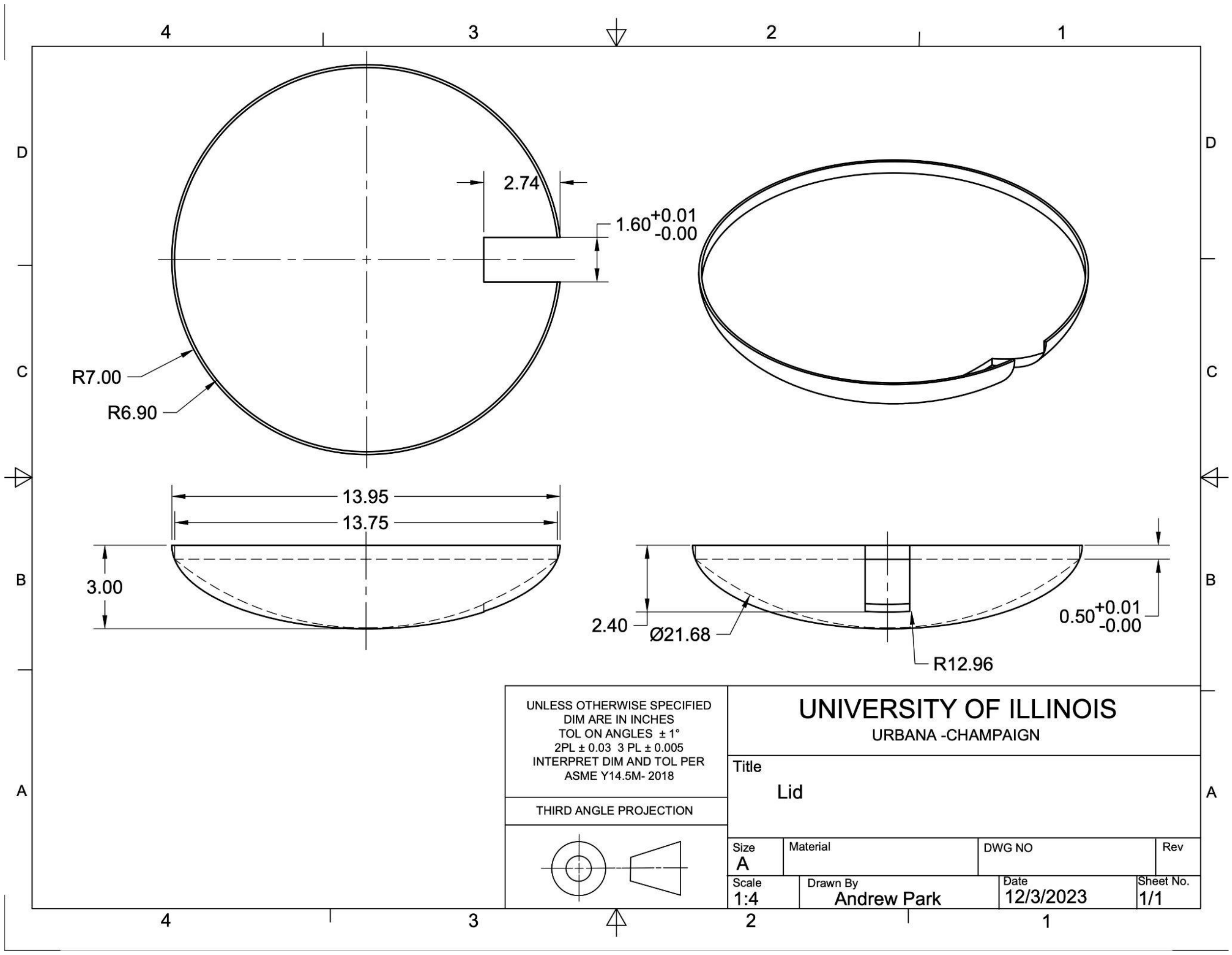

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UNIVERSITY OF ILLINOIS
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Andrew Park
Date
12/3/2023
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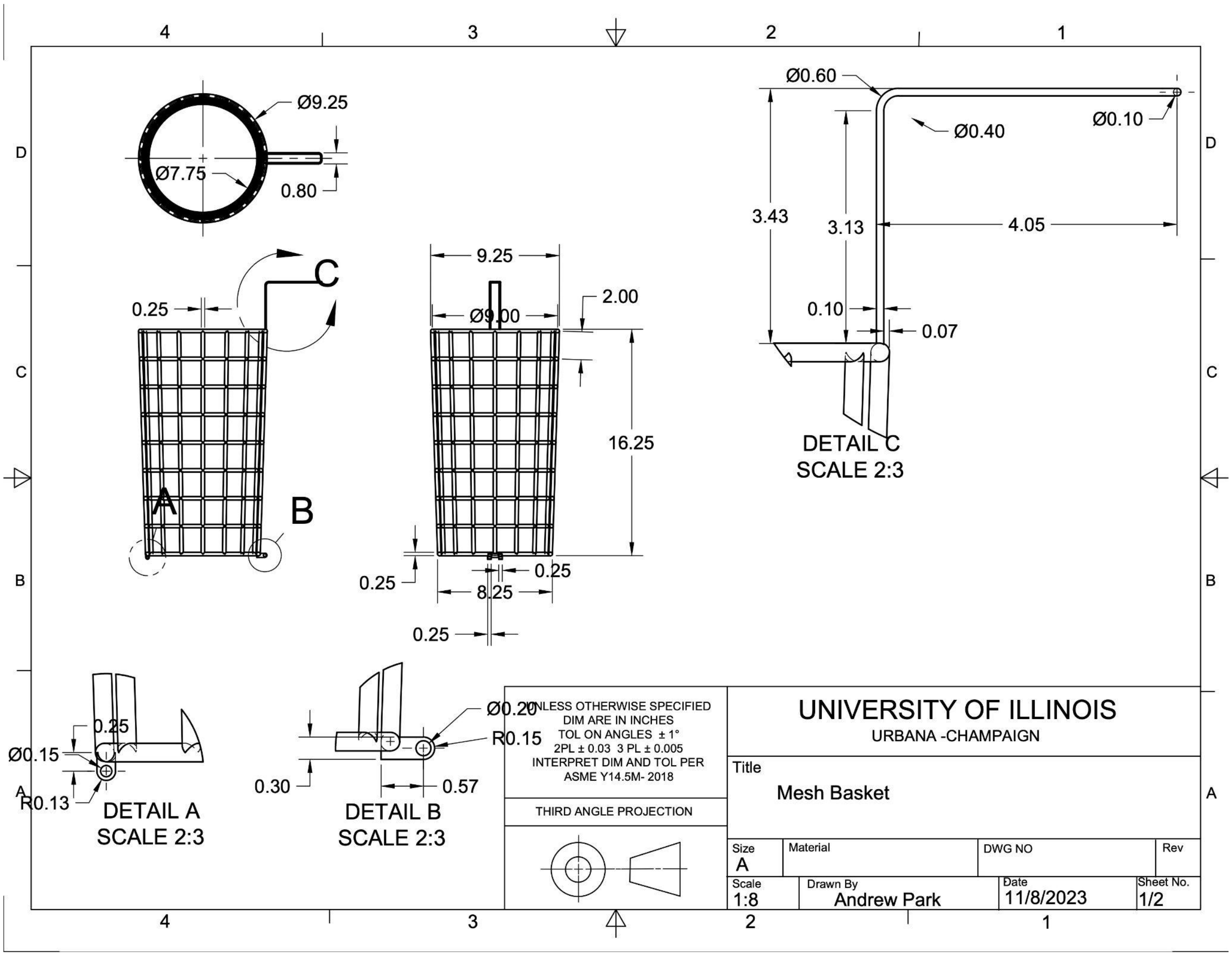

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THIRD ANGLE PROJECTION

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URBANA -CHAMPAIGN

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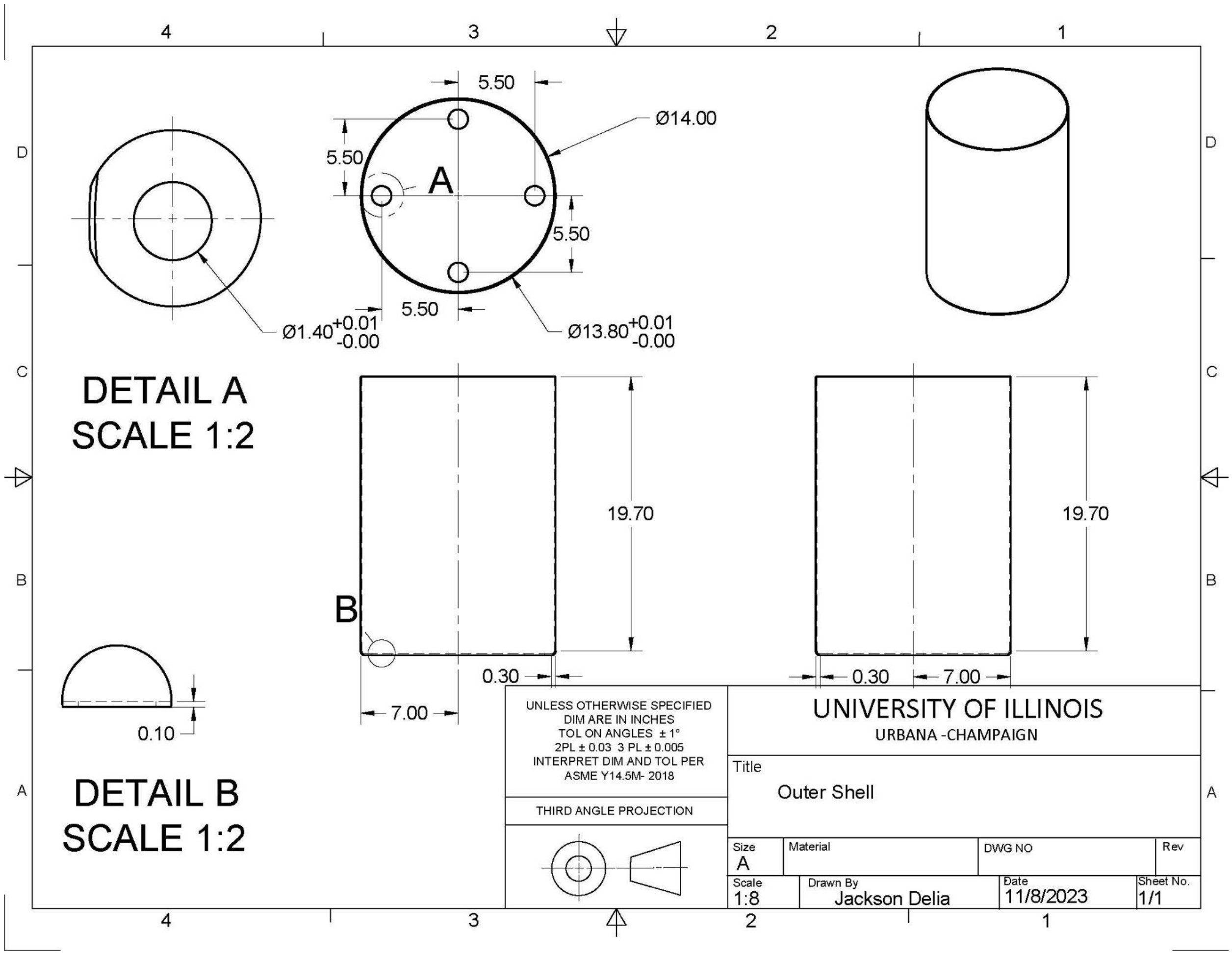
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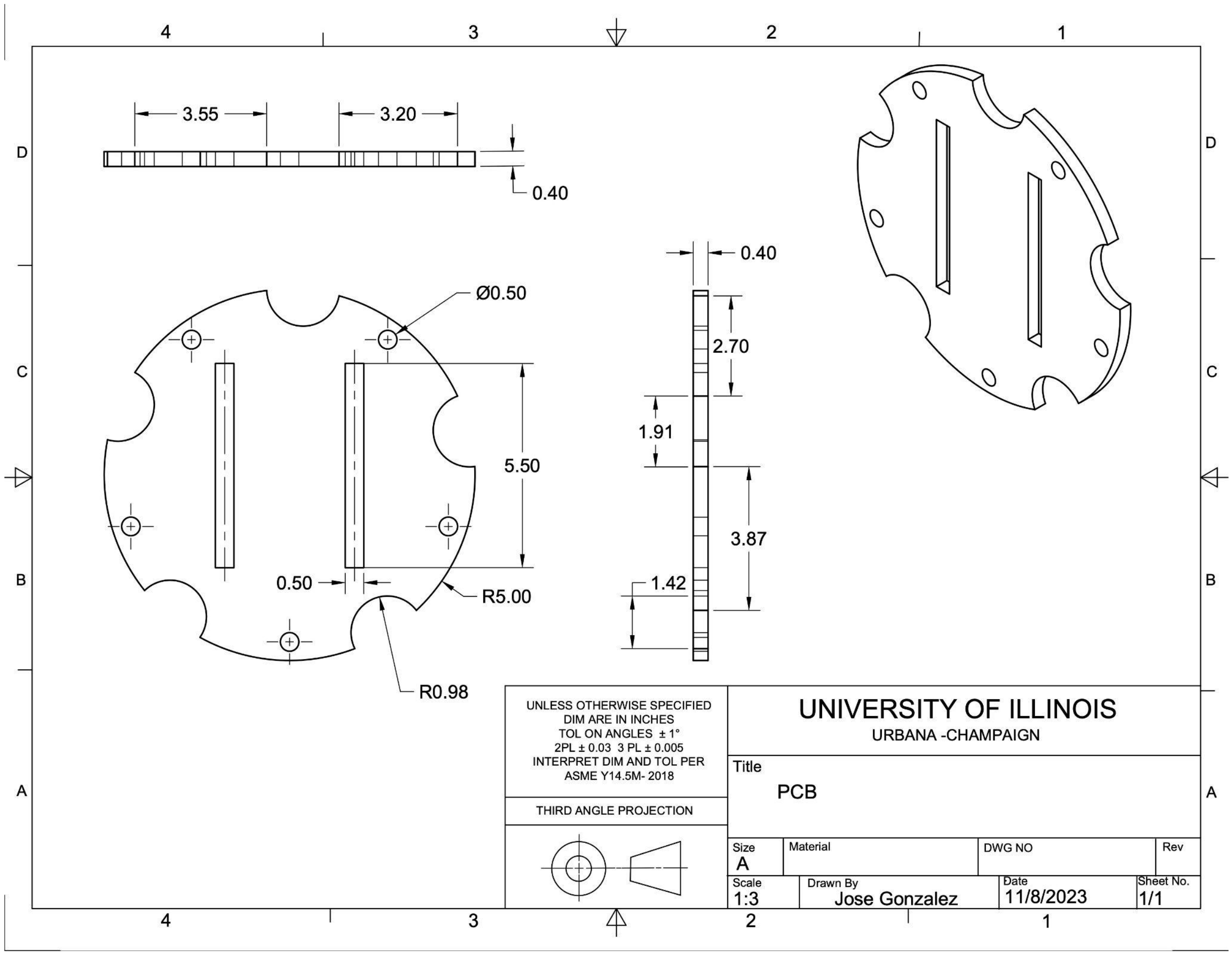
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UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
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Jose Gonzalez
Date
11/8/2023
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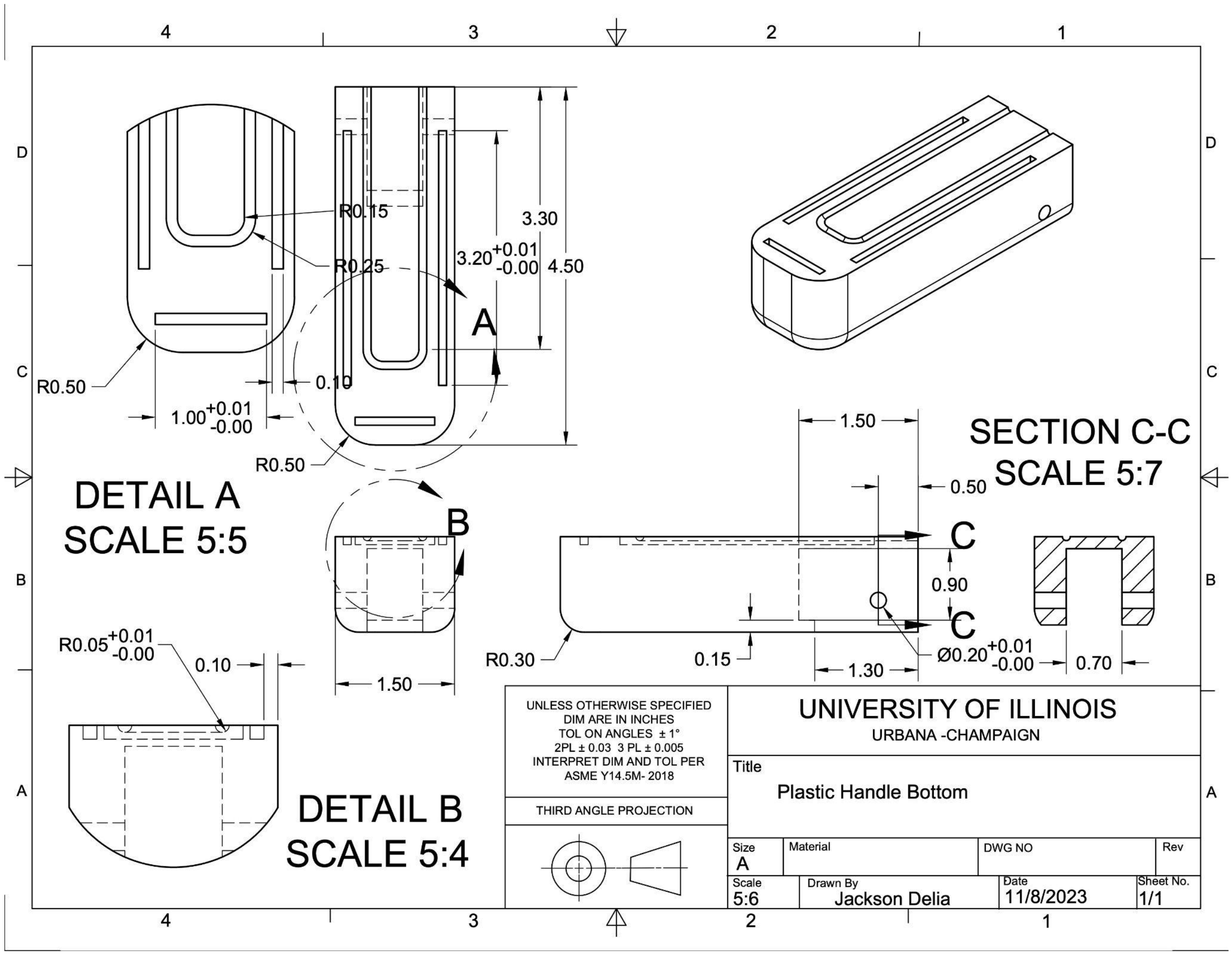
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DETAIL A
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2PL ± 0.03 3 PL ± 0.005
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UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
Title
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Jackson Delia
Date
11/8/2023
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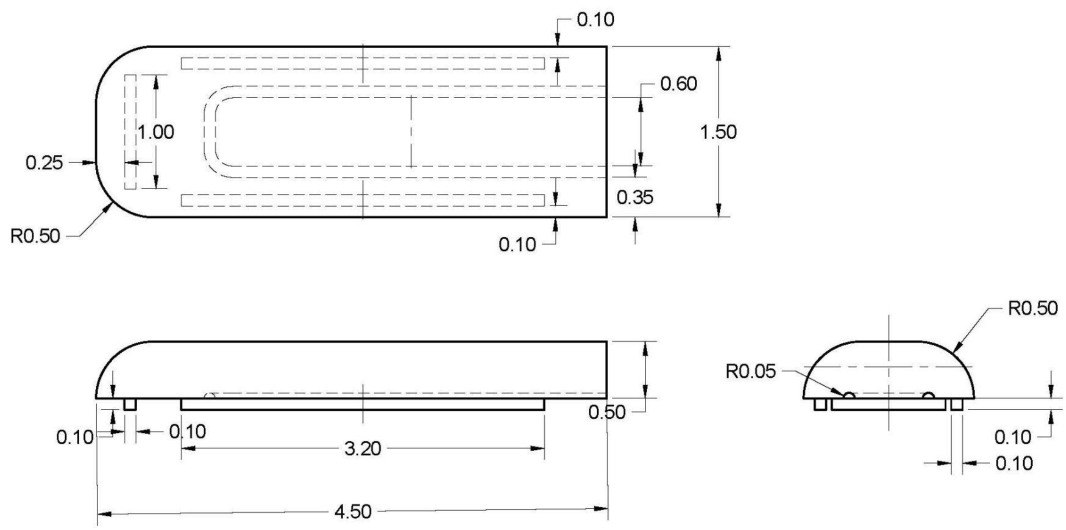

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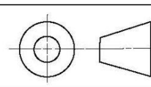
THIRD ANGLE PROJECTION



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Title
Plastic Handle Top

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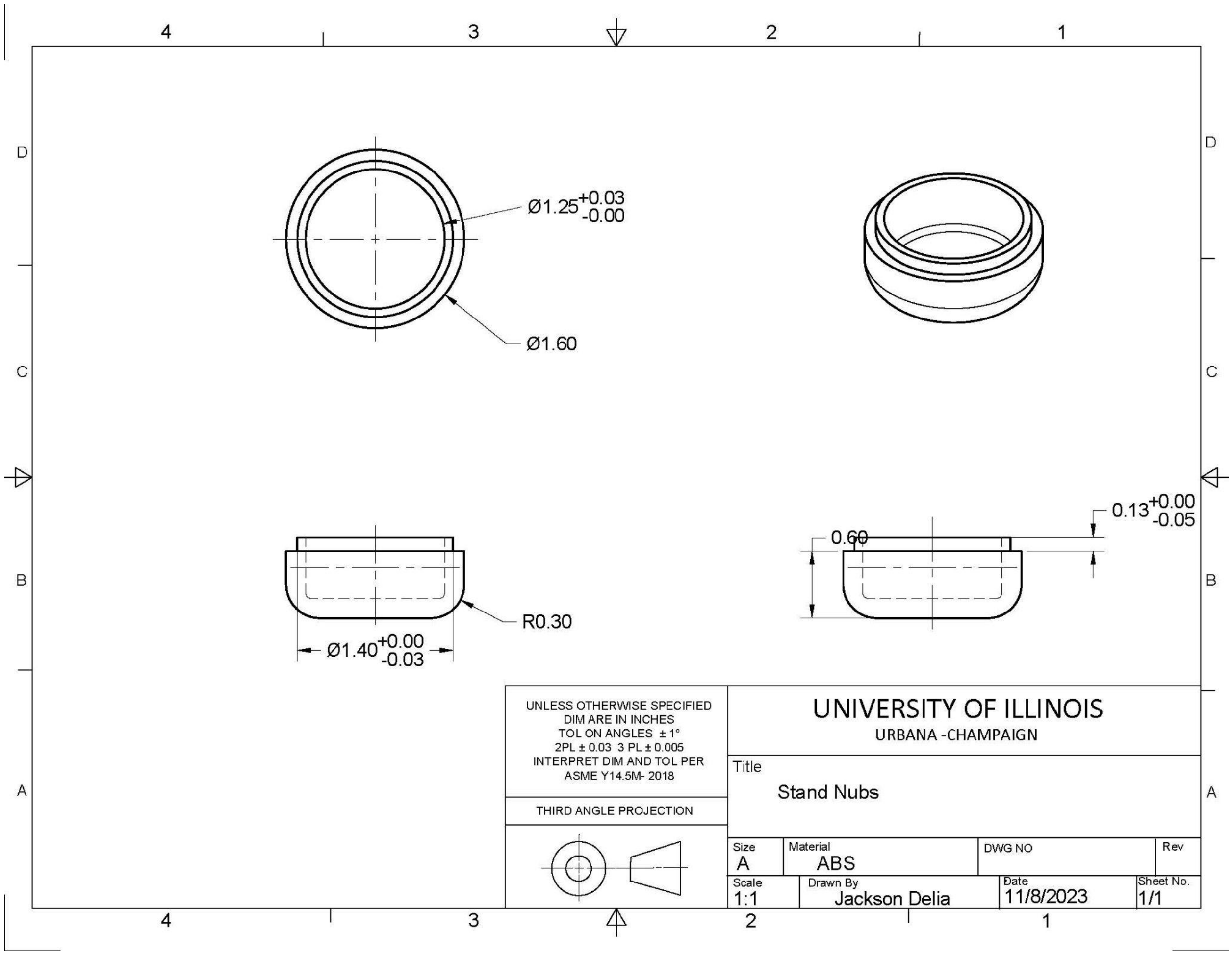
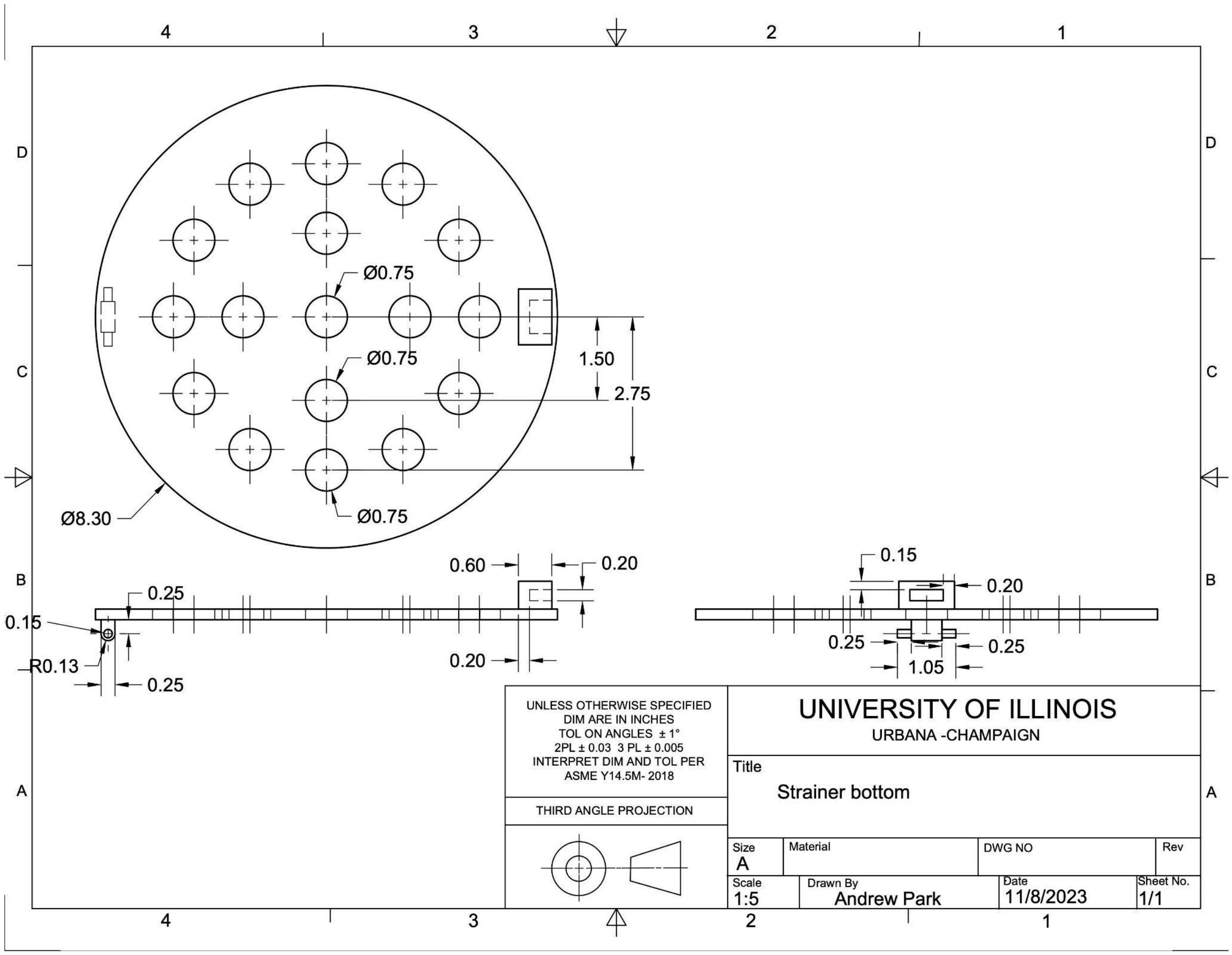


UNLESS OTHERWISE SPECIFIED DIM ARE IN INCHES TOL ON ANGLES ± 1° 2PL ± 0.03 3 PL ± 0.005 INTERPRET DIM AND TOL PER ASME Y14.5M- 2018	UNIVERSITY OF ILLINOIS URBANA -CHAMPAIGN			
	Title: Stand Nubs			
THIRD ANGLE PROJECTION	Size: A	Material: ABS	DWG NO	Rev
	Scale: 1:1	Drawn By: Jackson Delia	Date: 11/8/2023	Sheet No.: 1/1



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2PL ± 0.03 3 PL ± 0.005
INTERPRET DIM AND TOL PER
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UNIVERSITY OF ILLINOIS
URBANA -CHAMPAIGN
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Strainer bottom
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Material
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Andrew Park
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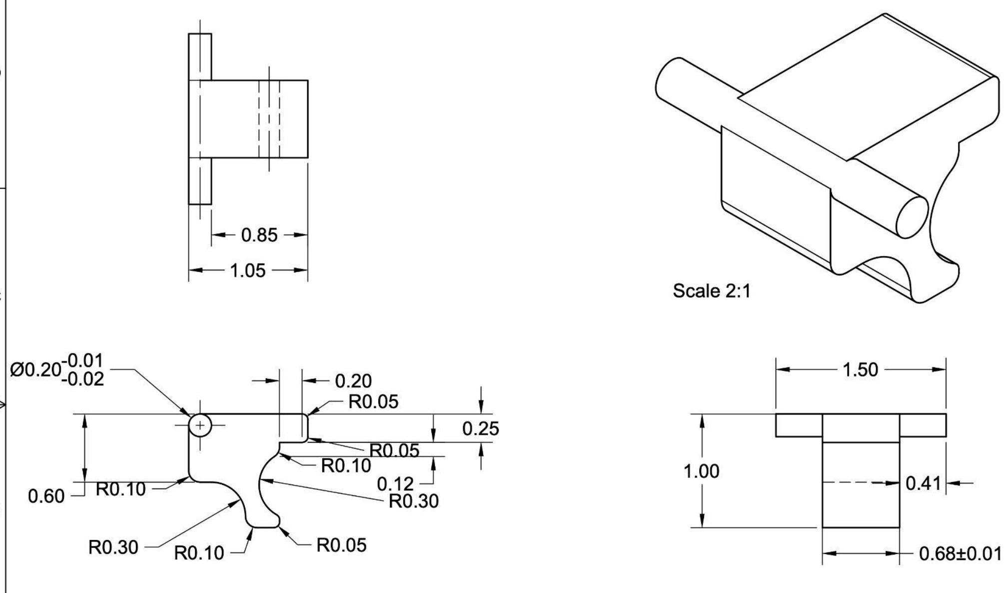

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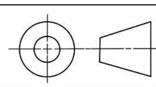
THIRD ANGLE PROJECTION



UNIVERSITY OF ILLINOIS
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Title
Trigger

Size	Material	DWG NO	Rev
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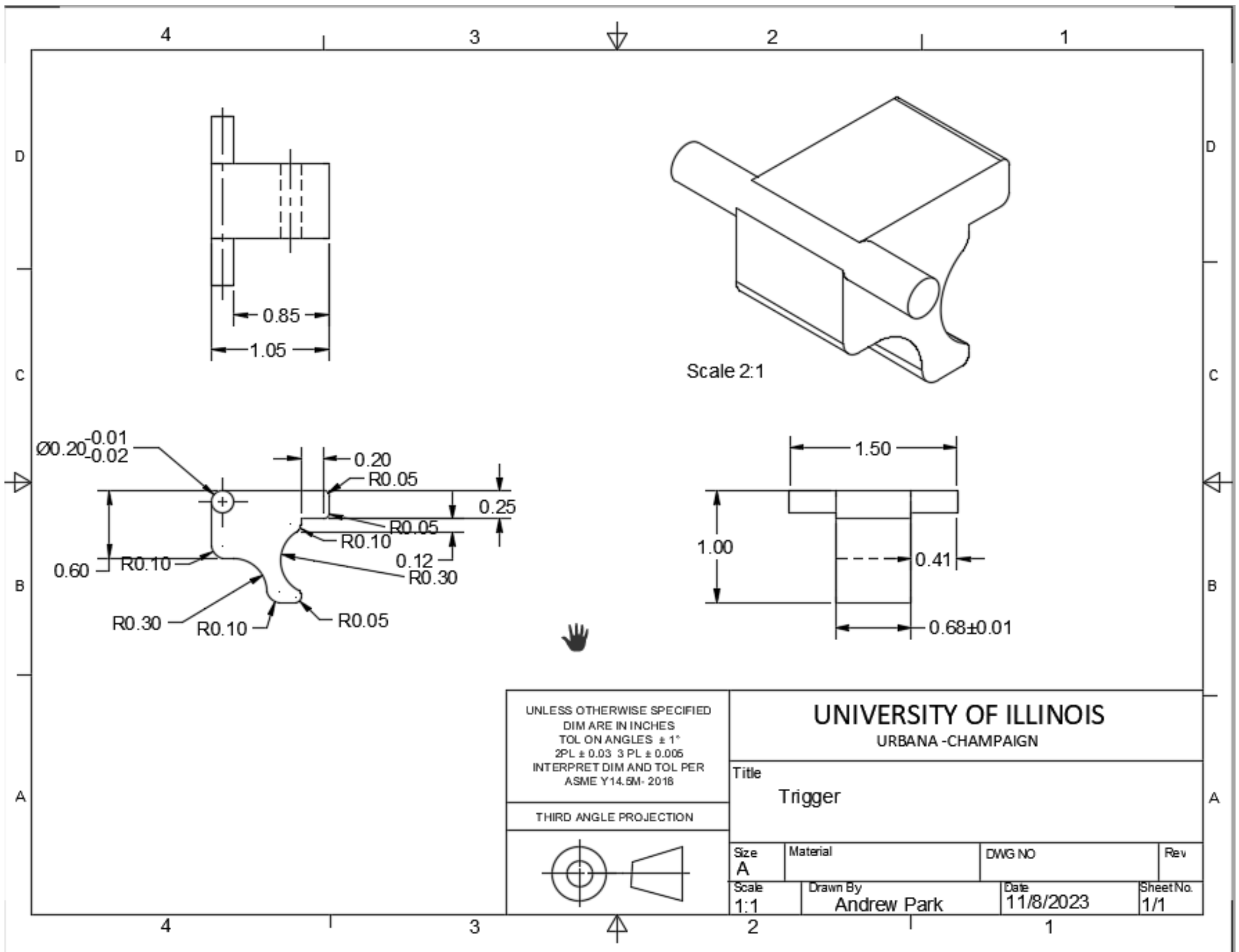
Scale	Drawn By	Date	Sheet No.
1:1	Andrew Park	11/8/2023	1/1

Tolerance Analysis:

For the trigger, the rod extending from the top needs to have a toleranced thickness, as well as the thickness of the body of it, so that way it will be able to fit in the lower handle. Every other dimension doesn't tightly fit against any other part, and tolerances are particularly important.



Rod tolerances:

To make sure that the rod fits tightly in the holes in the handle, it will have a base size of 0.20 inches, with an upper tolerance of 0.19 inches, and a lower tolerance of 0.18 inches. The base size of the hole will be 0.20 inches so it is important that the tolerances of the rod allow it to be smaller than the hole, so it will fit inside. This will provide an allowance of 0.01 inches and a clearance of 0.02 inches between the shaft and the hole.

Thickness tolerances:

The thickness of the trigger will be 0.68 inches, +/- 0.01 inches. It needs to fit into a gap that is 0.70 inches thick, which will provide an allowance of 0.01 inches and a clearance of 0.03 inches. Fitting tightly is not important, and could actually cause damage due to friction in the long run, and allowing a little bit of space between the trigger and the lower handle walls will deter this problem.

Materials, Manufacturability, and Cost Analysis:

Part #	Description	Material and Manufacturing Method	Part Cost (fully burdened and catalog)	Quantity	Total Part Costs	Investment Costs
Part 1	Latch	Sheet Metal- ANSI 2007 Aluminum: Die Casting	0.85	1	0.85	400.97
Part 2	Mesh Basket	Wire Forming	12.48	1	12.48	59,091.55
Part 3	Strainer Bottom	Sheet Metal- ANSI 1050A Aluminum: Die Casting	2.77	1	2.77	41,093.47
Part 4	Plastic Handle Top	Molded Plastic- ABS: Injection Molding	3.12	1	3.12	10,017.07
Part 5	Latch Connector	Sheet Metal- AISI 1020 Steel, Cold Worked	3.63	1	3.63	0
Part 6	Plastic Handle Bottom	Molded Plastic- ABS: Injection Molding	16.75	1	16.75	20,647.31
Part 7	Inner Shell	Sheet Metal- ANSI 3003 Aluminum: Die Casting	14.20	1	14.20	25,452.52
Part 8	Outer Shell	Molded Plastic- ABS: Injection Molding	9.11	1	9.11	44,543.09
Part 9	Stand Nubs	Molded Plastic- ABS: Injection Molding	0.42	4	1.68	9,053.04
Part 10	Lid	Molded Plastic- ABS: Injection Molding	7.08	1	7.08	26,360.98
Part 11	Trigger	Molded Plastic- ABS: Injection Molding	2.74	1	2.74	9,209.49
Part 12	PCB	Sheet Metal	4.99	1	4.99	43,661.95
				TOTALS	79.40	289,531.45

- Latch
  - Due to close proximity of the inner shell, the latch needs to be heat resistant, so it will be made of aluminum, which will be done using progressive die casting.
- Mesh Basket
  - The mesh basket is going to be made out of wire, since subtractive manufacturing would be wasteful and difficult.
- Strainer Bottom
  - Strainer bottom will be made using die casting and aluminum since it is one solid, thin piece that will cool quickly.
- Plastic Handle Top
  - The top of the plastic handle will be injection molded. Due to the extrusions connecting it to the bottom handle, the draw direction will be parallel to these extrusions.
- Latch Connector
  - The latch connector is a thin strip of metal with uniform thickness allowing for easy sheet metal manufacturing.
- Inner Shell
  - The inner shell will be formed using die casting, since it is thin aluminum with uniform thickness. It will be made out of metal since it has to be heat resistant, unlike the outer shell, because it will contain the boiling water.
- Outer Shell
  - The outer shell will be injection molded. Since there are holes out of the top and bottom of the shell, the draw direction will be vertical, which is normal to the holes.
- Stand Nubs
  - The stand nubs will be injection molded, and will have a draw direction parallel to the thin wall on top to allow the molds to come apart.
- Lid
  - The lid will be injection molded. The draw direction will be vertical, since it is hollow and the mold wouldn't be able to come apart otherwise.
- Trigger
  - The trigger will be injection molded, in a direction parallel to the rod on top that will be inserted into the handle.

Conclusion:

Going forward, it would be best to conduct interviews and collect data about how many people would be interested in buying an EZ Boiler. Finding ways to cut costs and improve our design based on these interviews would also be a next step. With a current manufacturing cost of about $80, it could be sold for $100 with $20 dollars of profit per unit. With an initial investment of $289,531, 14477 units would need to be sold to break even. Considering we would intend to sell many more than this number of units, the risk wouldn't be very high. Since many of the parts required intricate designing, as well as a mechanism to release the bottom of the strainer, the group put considerable effort in making a product with a reasonable amount of complexity.