Criterion A

A.1 Describe an appropriate problem that leads to a design opportunity.

Situation:

Most people shower an average of twice a day, each lasting approximately eight minutes, for a total of close to 20 minutes in the shower per day (Lindberg). While using the shower, most people use a various assortment of products including shampoos/conditioners, soaps, face washes, facial scrubs, body sponges and nail brushes (Brenner, 2023).

Problem Statement:

In an interview with my clients (a 14-year-old boy and a 47-year-old woman), they have identified that they struggle with the lack of organization. The shower they use does not currently have any space to store all of their products in a hygienic and convenient manner. They currently store their product on the side of the bathtub (See Figure 1. A) which is unorganized and keeps the products in a high-moisture environment that is susceptible to mold. They are stored at a height of 40 cm which is low compared to them which means they need to bend down which creates stress on their lower back (See Figure 1. B and Tables 1 and 2). Furthermore, there is not enough space for all of their products which means they have to leave the shower to get their products which creates a slipping hazard (See Figure 2. C).

Figure 1. Bathtub used by clients

Figure 1B. Bathtub dimensions

Figure 2A. Shower used by clients

Figure 2B. Shower wall (made of ceramic tiles) dimensions

Figure 2C. Limited space for products

Table 1. American Male height percentiles (Cityu)

Parameter	Percentile			Client 1
	5%	50%	95%	
Height (m)	1.64	1.76	1.87	1.65
Shoulder Height (m)	1.33	1.44	1.55	1.35
Arm Reach (m)	0.73	0.79	0.85	0.75

Table 2. American Female height percentiles (Cityu)

Parameter	Percentile			Client 2
	5%	50%	95%	
Height (m)	1.52	1.63	1.73	1.55
Shoulder Height (m)	1.23	1.33	1.43	1.23
Arm Reach (m)	0.66	0.72	0.78	0.69

Market analysis of existing solutions:

Figure 3. Solution 1 (Shein)

Figure 4. Solution 2 (Lanboo)

Figure 5. Solution 3 (Payhip)

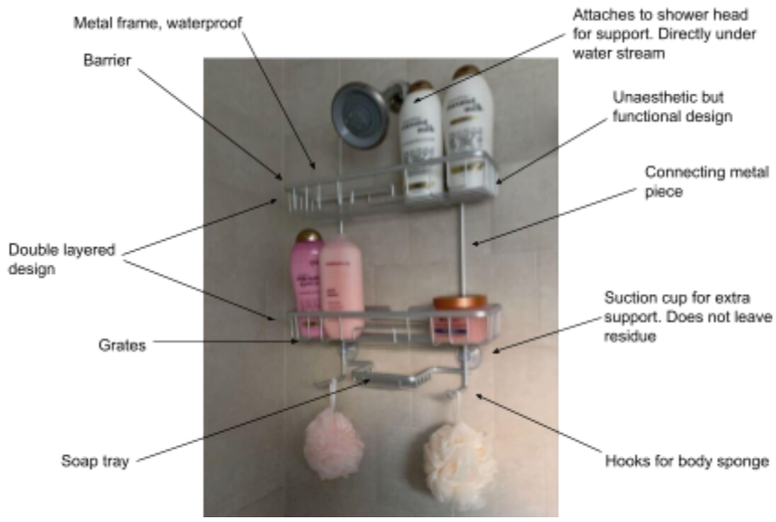


Figure 6. Solution 4 (IKEA)

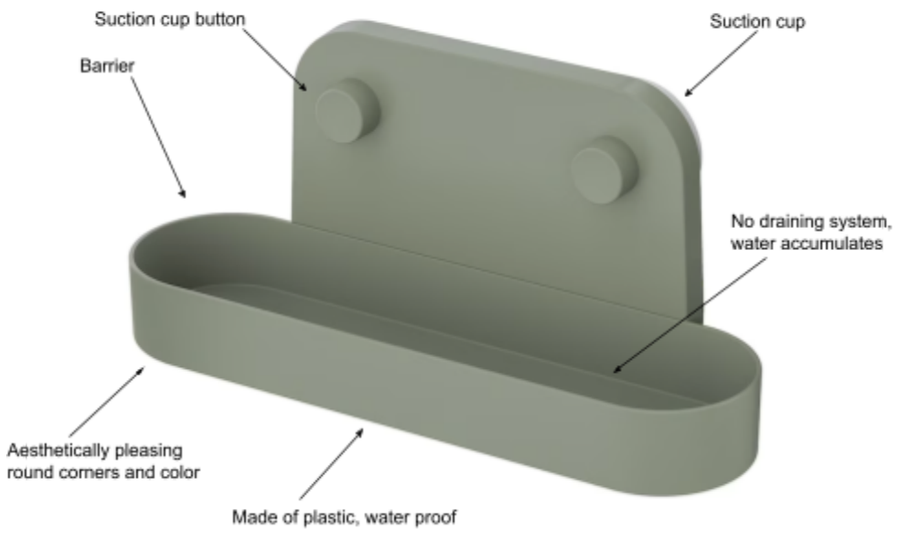


Figure 7. Solution 5 (Jumia)

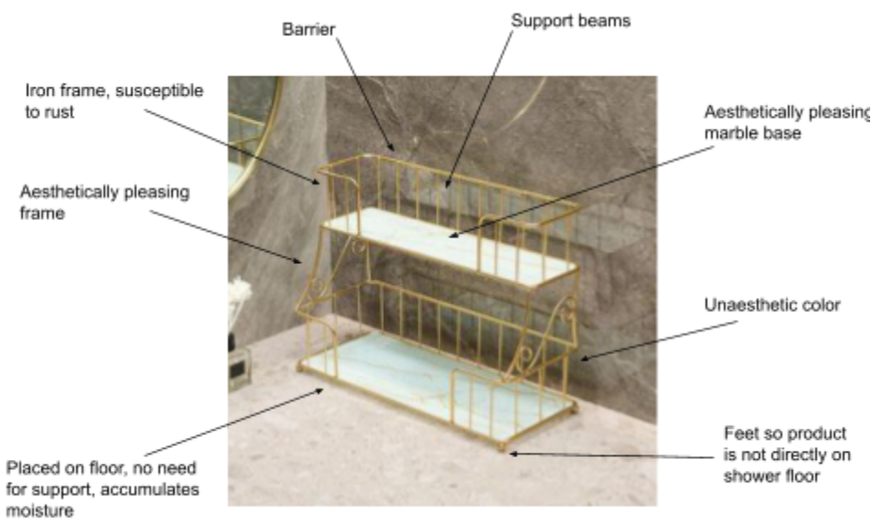


Figure 8. Diagram showing top view of all products

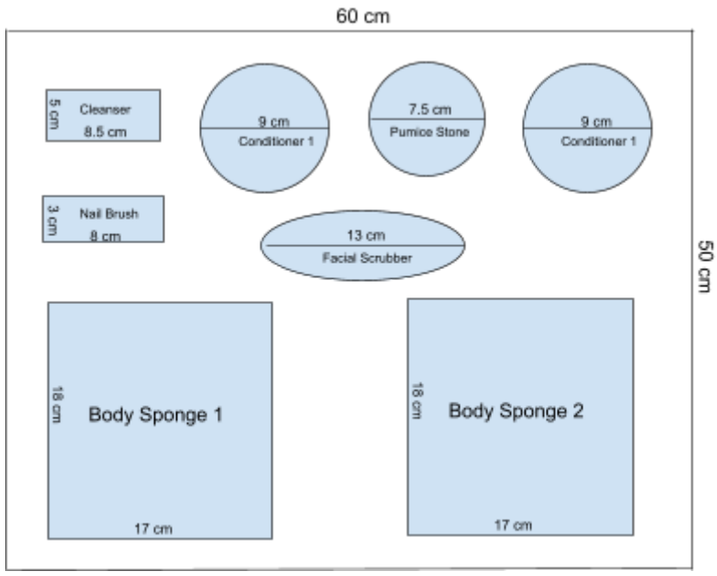
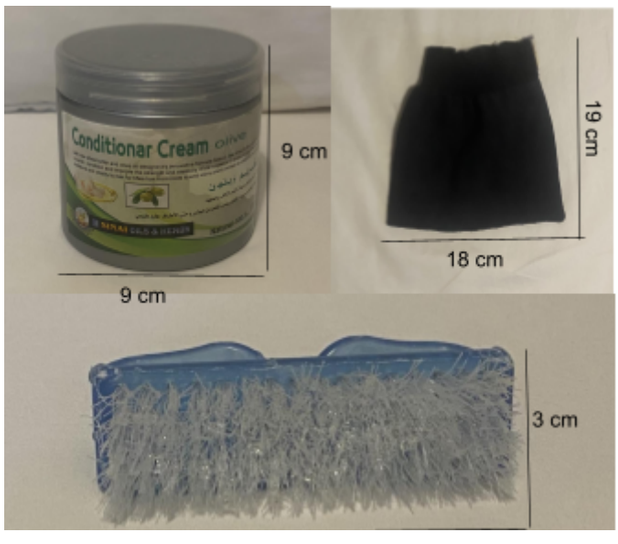


Figure 9. Dimensions of products used by Client 1

Figure 10. Dimensions of products used by Client 2



A.2 Develop a detailed brief that identifies the relevant parameters of the problem.

The main problem that my clients face is that their shower is poorly organized and does not currently have enough space to conveniently and hygienically store all their hygiene products. The primary goal is to design and build a one-off system to organize the products used in the shower by my two clients. From a functional standpoint, the design will have a shelf-like structure with room to store all products in a neat and safe manner. Furthermore, my product will do so in a hygienic manner as it will be positioned and designed to prevent water and germs from accumulating. From an aesthetic standpoint, the design should be simplistic and elegant and not take up too much space (see Figure 2B).

Success Criteria:

- Must hang from shower wall
- Must have designated space for all products
- Must be strong enough to hold all products
- Must be water-resistant
- Should be a simple yet functional design
- Custom-designed size and height for clients
- Will be made from sustainable materials
- Design must be affordable to my clients

A3. Develop a design specification that justifies the requirements, based on the outcomes of the research.

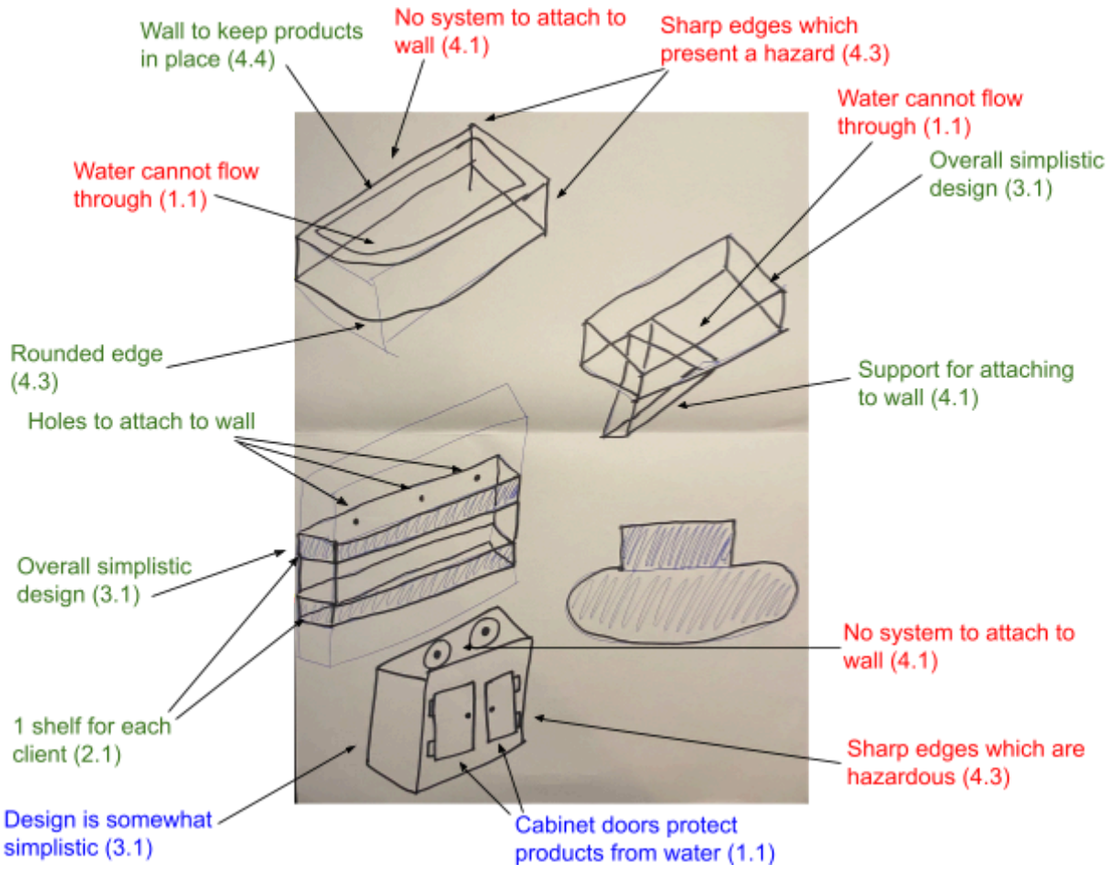
Category (in order of importance)	**Specification**	**Justification**	**Testing Procedure**
1. Function and Features	1.1 The solution will be constructed so that water flows through it.	This will prevent water from accumulating which will stop mold and bacteria from building up (see Figure 4) (CDC).	Lab Testing/Field Research
2. Target Audience	2.1 The solution should be designed specifically for my clients	The solution is designed specifically for my two clients (14-year-old boy and a 47-year-old woman). As shown in Tables 1 and 2, they have varying anthropometric data in terms of their height, shoulder height, and arm reach. The solution must be created and positioned in a way that it is easily accessible by both clients.	Usability Testing/Interview
	2.2 The solution must have a total surface area of 450 cm^2.	As shown in Figures 8, 9, and 10, this is the minimum amount of space to store all products used by my clients in an organized manner.	Lab Testing
3. Aesthetics	3.1 The solution must have a simplistic design.	My clients have indicated that they want the design to be simplistic and elegant so it does not distract them while taking showers.	Lab Testing
	3.2 It will be a single base color such as white, grey, or black.		
4. Safety	4.1 The solution must be securely attached.	Since the solution will be supporting the combined weight of all the different products, it must be strong	Performance Testing

		enough to do so, and must also be securely attached to the ceramic tiled wall.	
	4.2 The solution must be strong enough to support approximately 2 kilograms.		
	4.3 The solution will have a smooth texture with no sharp corners.	Since my clients will be reaching to grab the products, I do not want them to accidentally injure themselves on a sharp corner or rough surface (Group, 2023).	Lab Testing
	4.4 The solution must have a barrier.	This will prevent the products from falling which is a safety hazard (see Figure 3).	Performance Testing
5. Materials	5.1 The solution will be made from pine wood.	Pine wood is cheap, lightweight, sustainable, and has an aesthetically pleasing appearance (Loffer, 2018).	Lab Testing
	5.2 The solution will be joined with wood glue.	This will ensure that it is securely joined without sacrificing aesthetics.	Performance Testing
	5.3 The solution must be protected from water damage.	Given that it is designed to be used in the shower, the solution must be protected from the water damage it will be exposed to. This can be done by finishing it with varnish/finishing oils, or by coating it fully with a sealant such as polyurethane (Vila, 2023).	Lab Testing
6. Production Constraints	6.1 The solution will be manufactured professionally.	This is the most convenient and affordable manufacturing technique given the scale and materials (Samani, 2020).	Market Research
	6.2 The solution must be manufactured between December 2023 and January 2024.	My clients have indicated that they would like to use to solution starting from the beginning of 2024.	Market Research
	6.3 The solution must cost less than 1000 EGP or 34 USD in total.	This will allow it to be within the affordable price range for my clients.	Market Research/Client Interview
7. Quantity	7.1 Two prototypes of the solution will be produced in total.	In order to fully explore the solution, 2 prototypes will be made. The first will be a styrofoam model which will be used to test the design from an aesthetic perspective. The second will be a 3D-printed model which will be used to ensure that the solution allows water to flow through it.	Client Interview

Criterion B

B1. Develops feasible ideas to meet appropriate specifications that explore solutions to the problem

Figure 11. Initial Sketches



*Green = Fully met, Blue = Partially met, Red = Not met

Figure 12. Initial Sketches

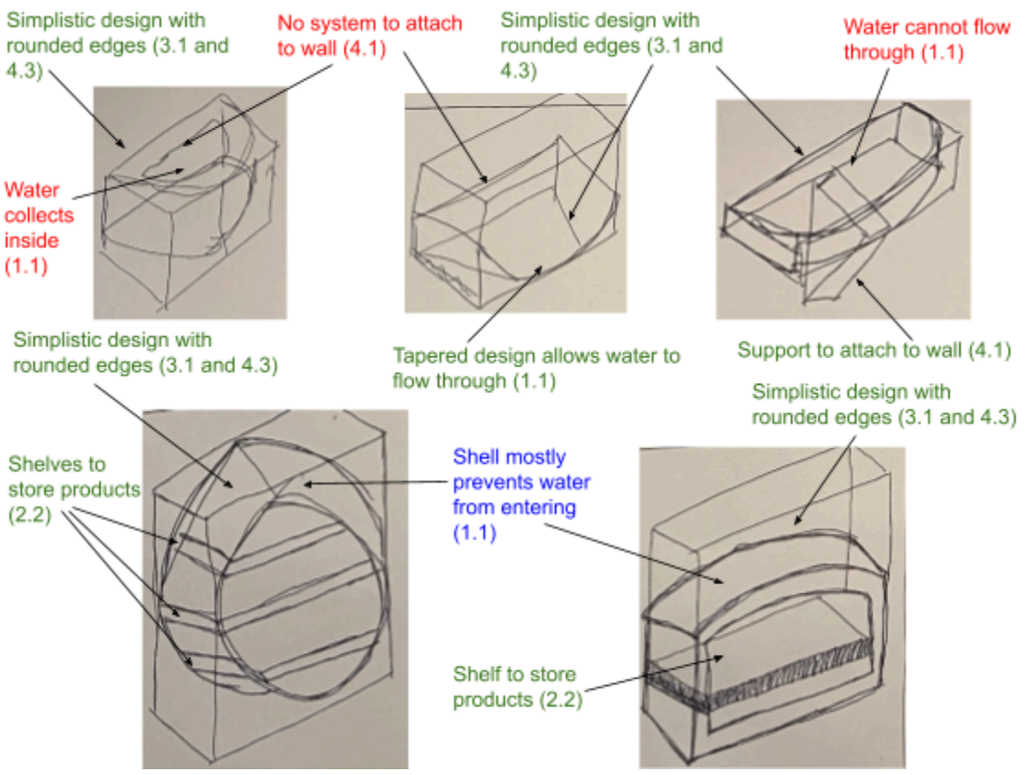


Figure 13. Initial Sketches

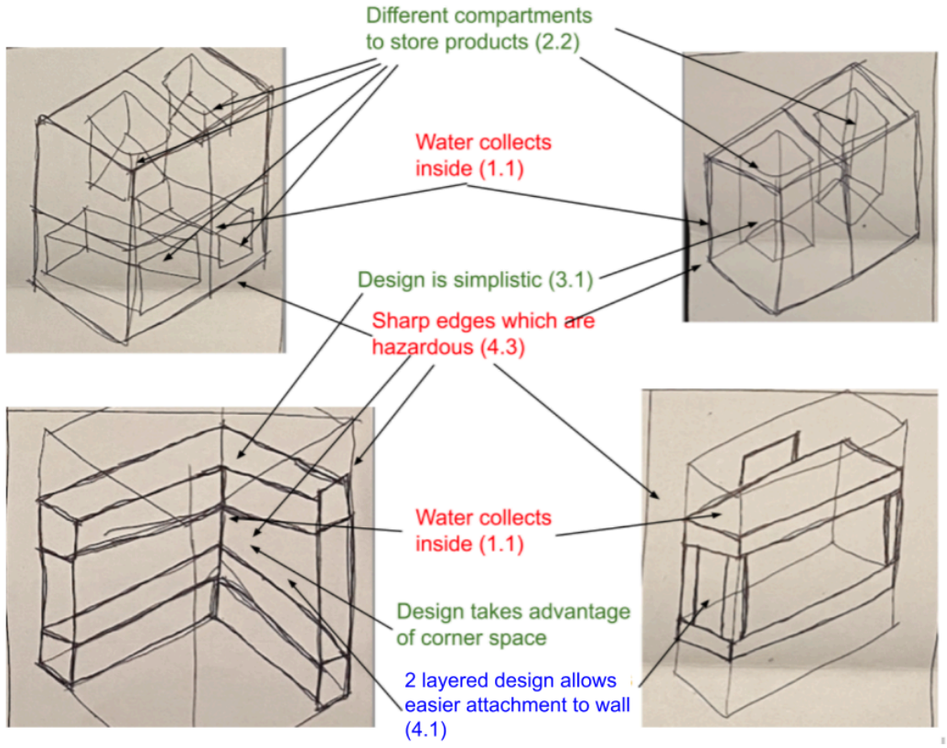


Figure 14. Idea #1

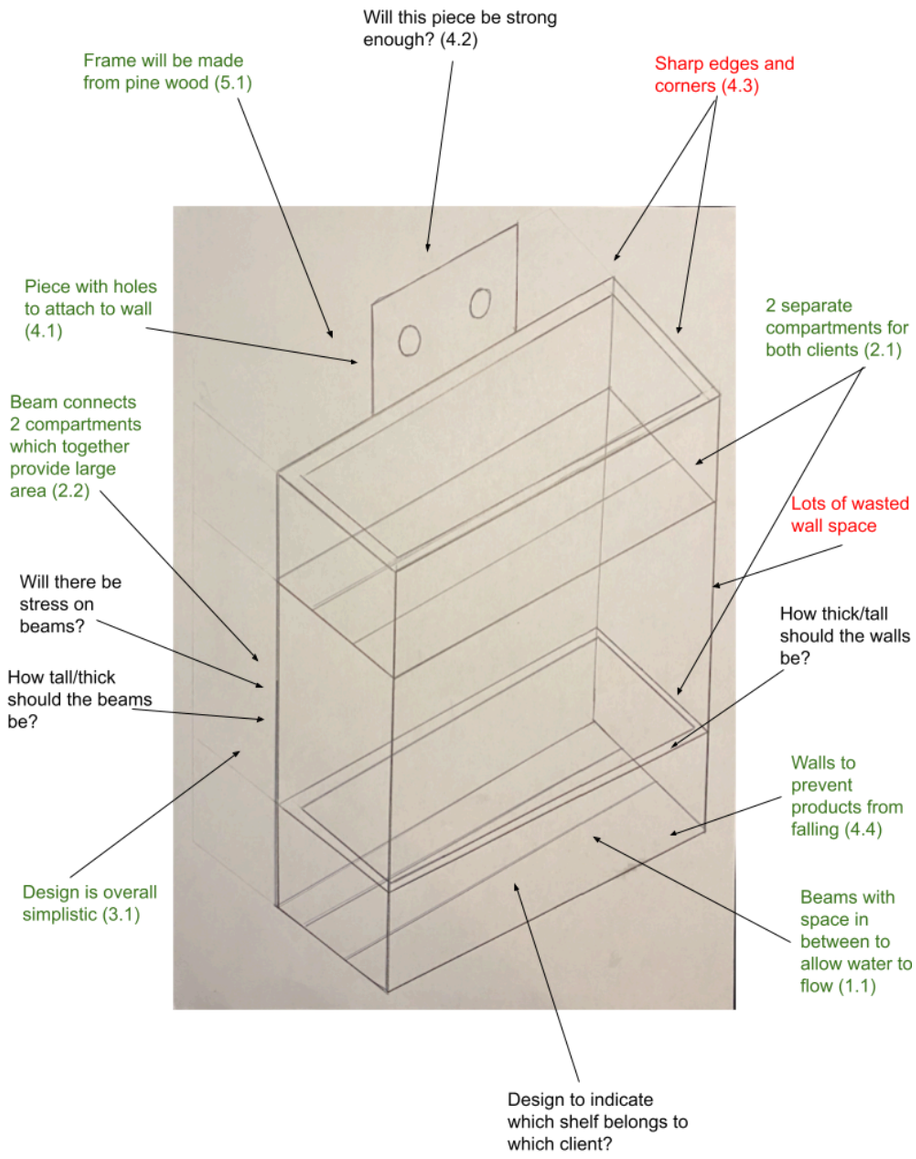


Figure 15. Idea #2

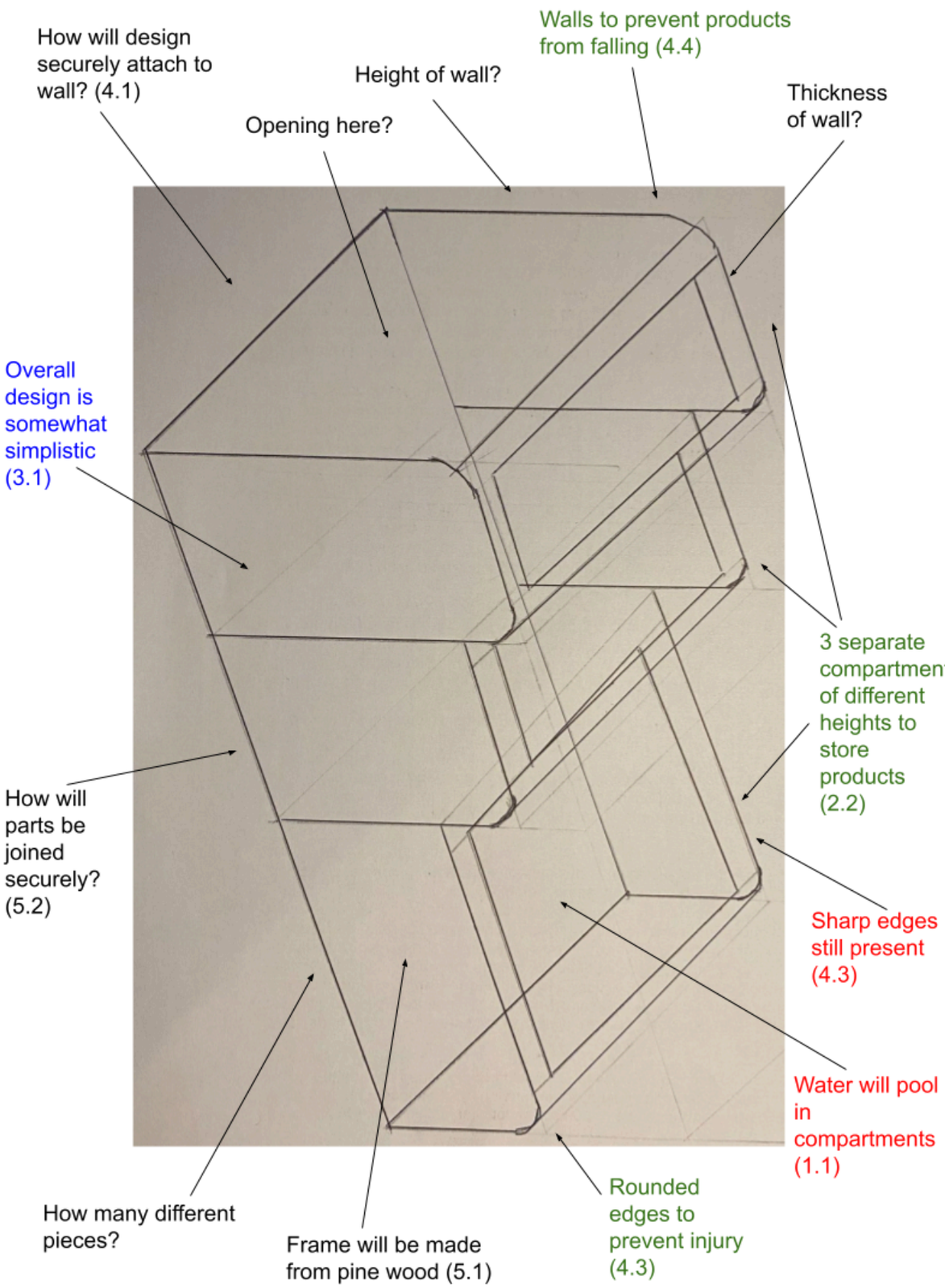


Figure 16. Idea #3

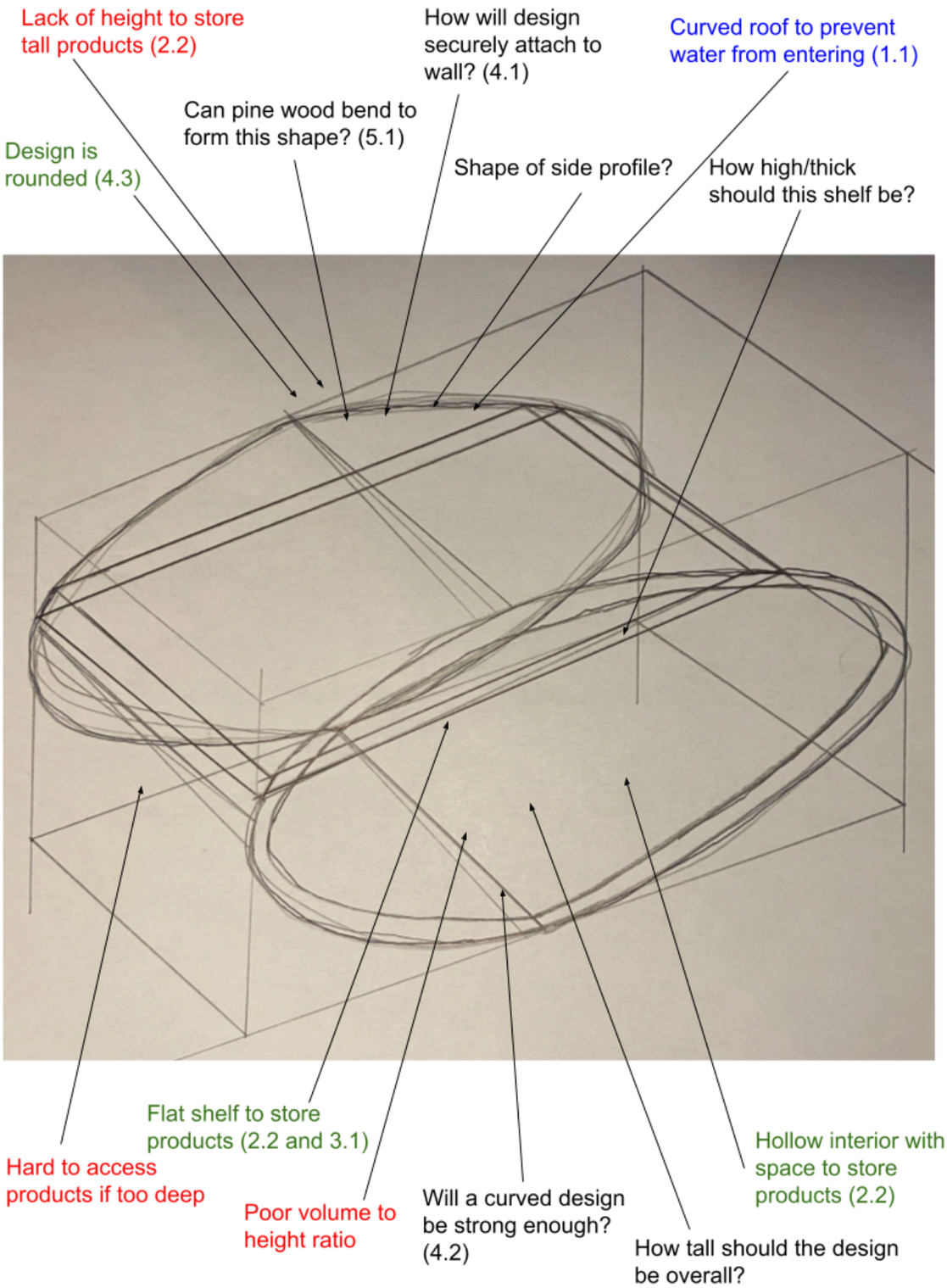
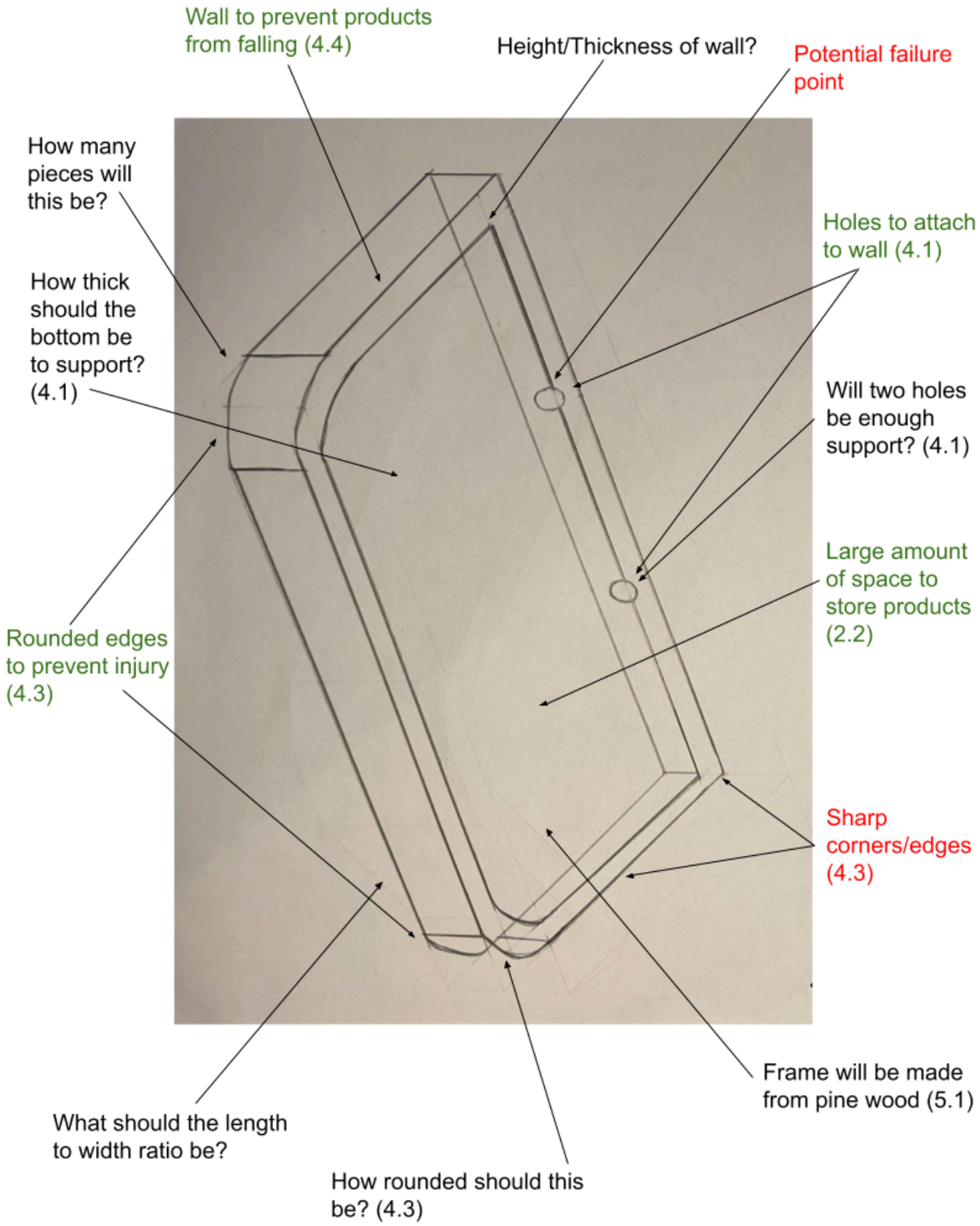


Figure 17. Idea #4



B2. Uses concept modeling and analyzes the outcomes to guide design development

Figure 18. Model #1 - Experimenting with different hooks/dowels

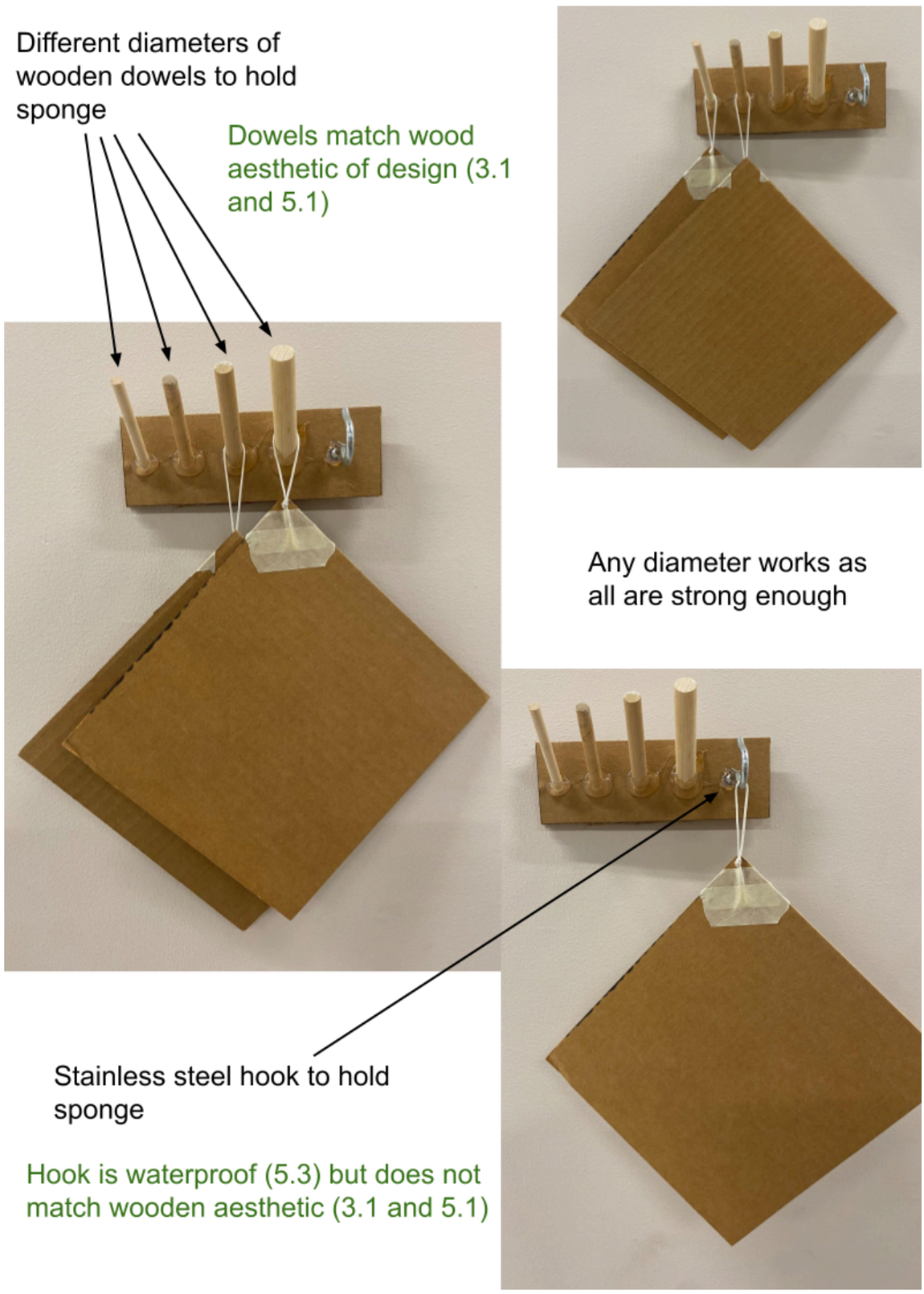


Figure 19. Model #2- Finite Element Analysis (FEA) of each model

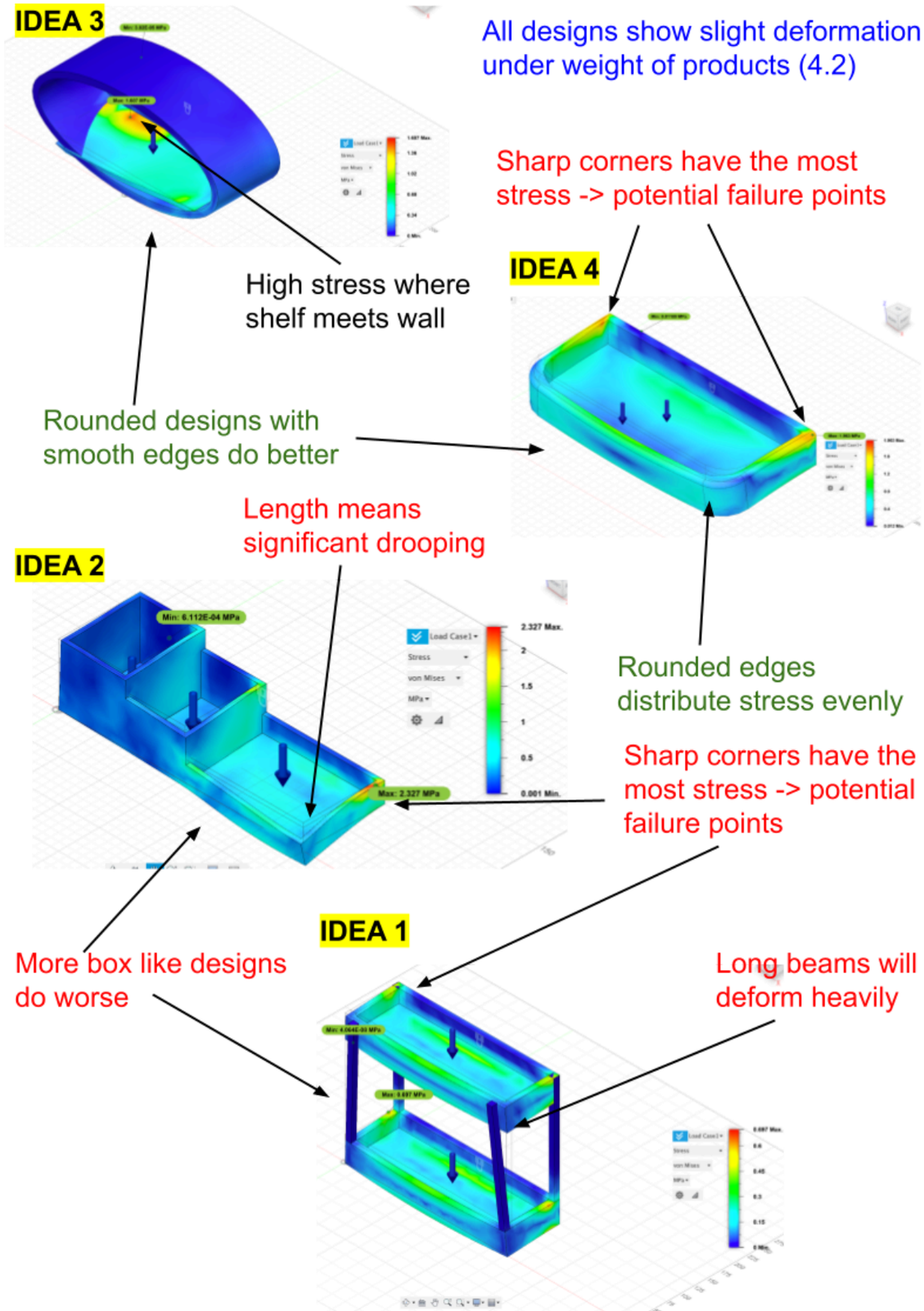


Figure 20. Model #3 - Cardboard Prototypes

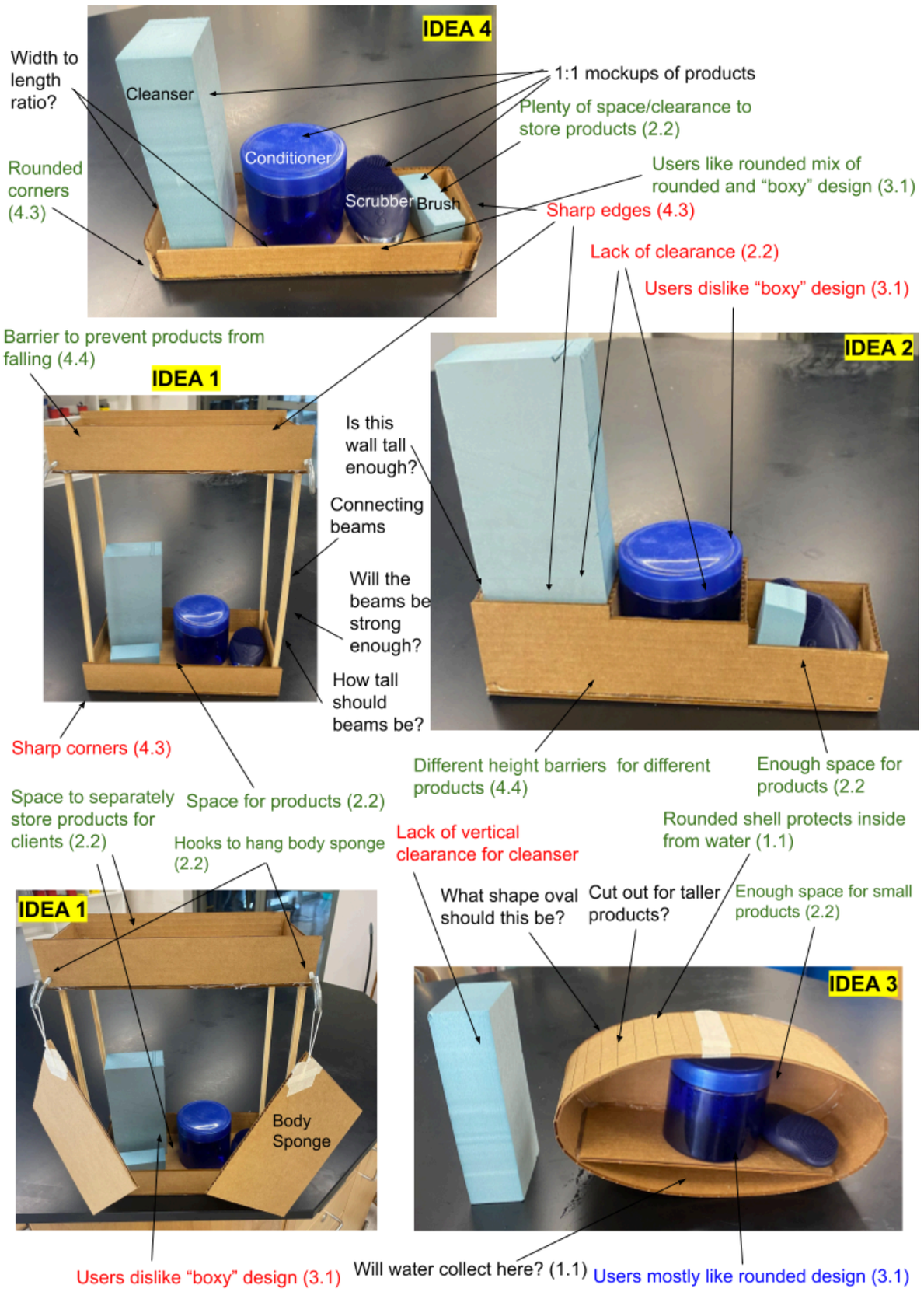


Figure 21. Model #4 - Joining Test

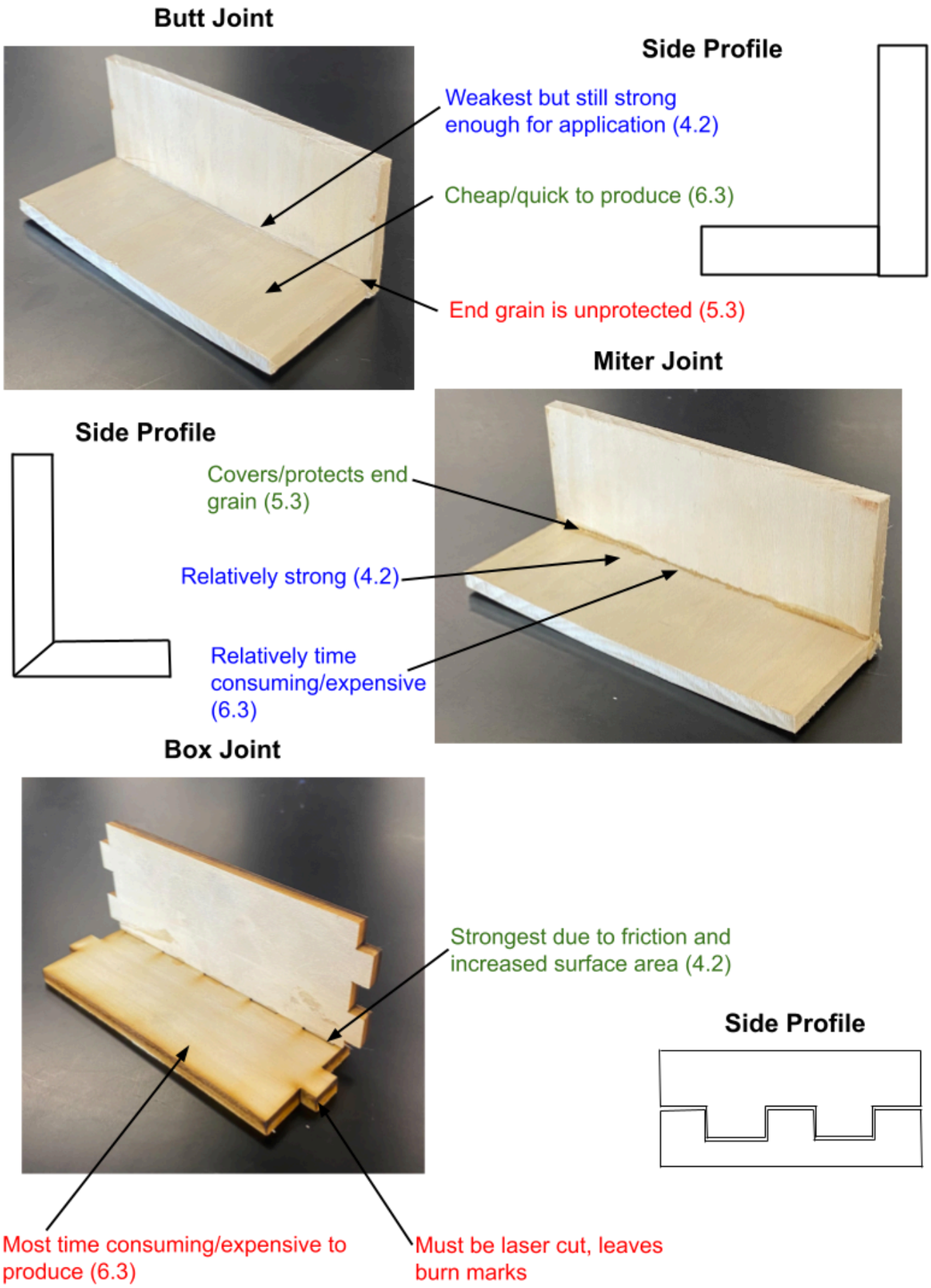


Figure 22. Computer-Aided Design (CAD) model of chosen idea

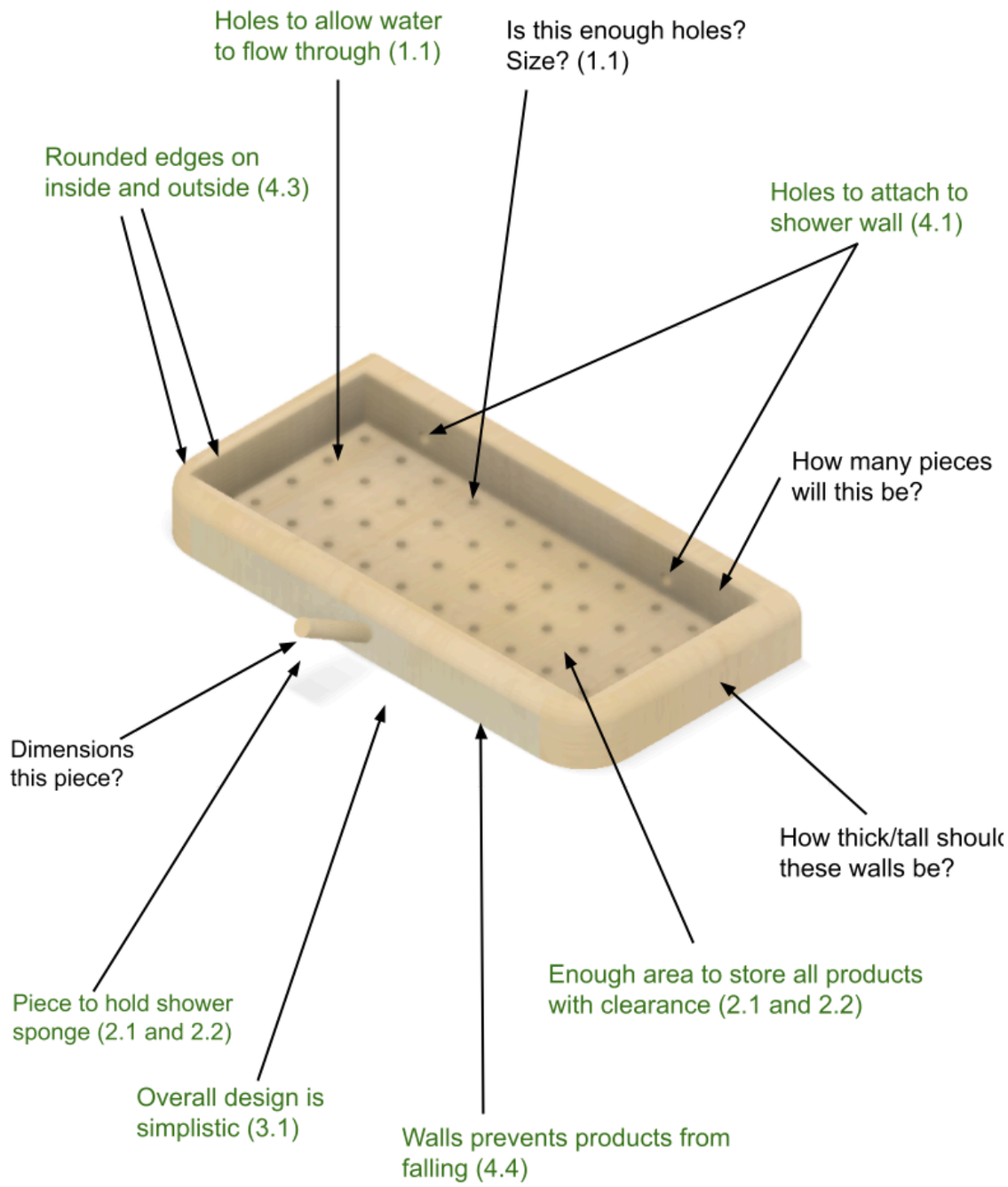
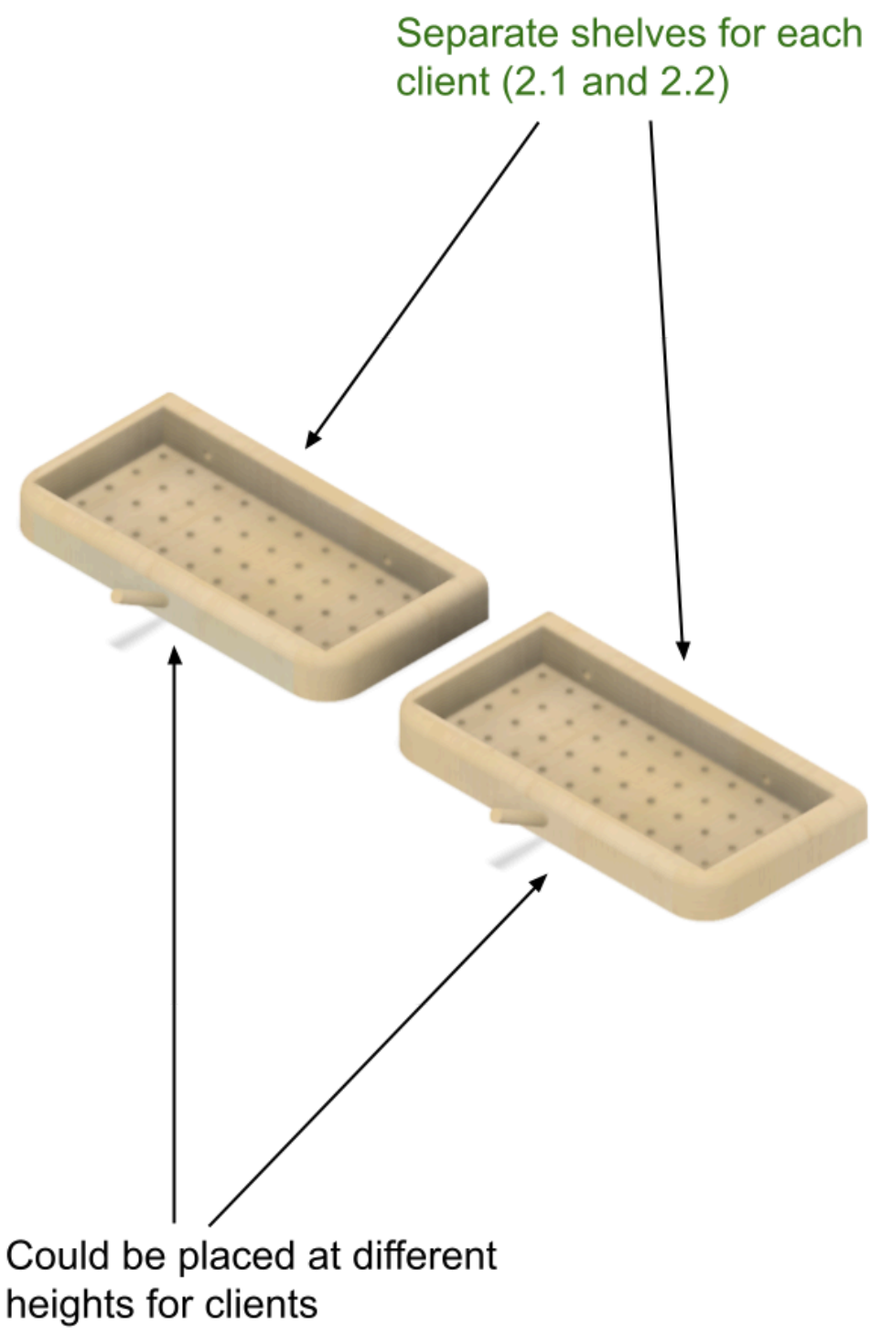


Figure 23. Second Computer-Aided Design (CAD) model of chosen idea



B3. Justifies an appropriate idea for detailed development

Justification:

The above design (Idea 4) has been chosen as it best covers all necessary criteria which means it is the best possible product for my clients. It best satisfies criteria 1.1 as the holes allow water to fully flow through without any chance of it pooling up. The design satisfies criteria 2.1 and 2.2 as it is specifically designed for my clients' needs. It has a total surface area of 450 cm^2 to store products, which allows plenty of clearance. Furthermore, the hook allows my clients to store a shower sponge in a hygienic manner without wasting space. As a whole, the design is simplistic which satisfies criteria 3.1. This was an important decision from an aesthetic point of view as I wanted the design to be elegant and unobtrusive. Another important consideration was how the design would attach to the shower wall (criteria 4.1). I decided the most effective way to do this would be by creating two small holes for screws or nails to fit in. This would be the best way to attach the product to the wall without taking up extra space. The design has an overall rounded look with very few sharp edges (criteria 4.3) which is beneficial for two reasons. Firstly, it is safer for my clients as sharp edges can be a hazard. Secondly, using FEA as shown in Figure 19, designs with a more rounded appearance can handle vertical stress better as they distribute the force better. Finally, criteria 4.4 was considered as the design has a small barrier (30 mm high) which prevents products from falling. The other designs (Ideas 1, 2, and 3) were not chosen as they did not fully meet the appropriate criteria. They did not match the aesethic appearance that my clients wanted, posed safety and structural concerns, and did not have the necessary space needed.

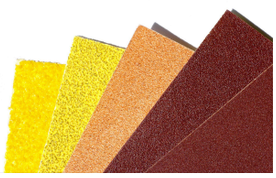
Criterion C

C.1 Justify the choice of appropriate materials, components and manufacturing techniques to make the prototype.

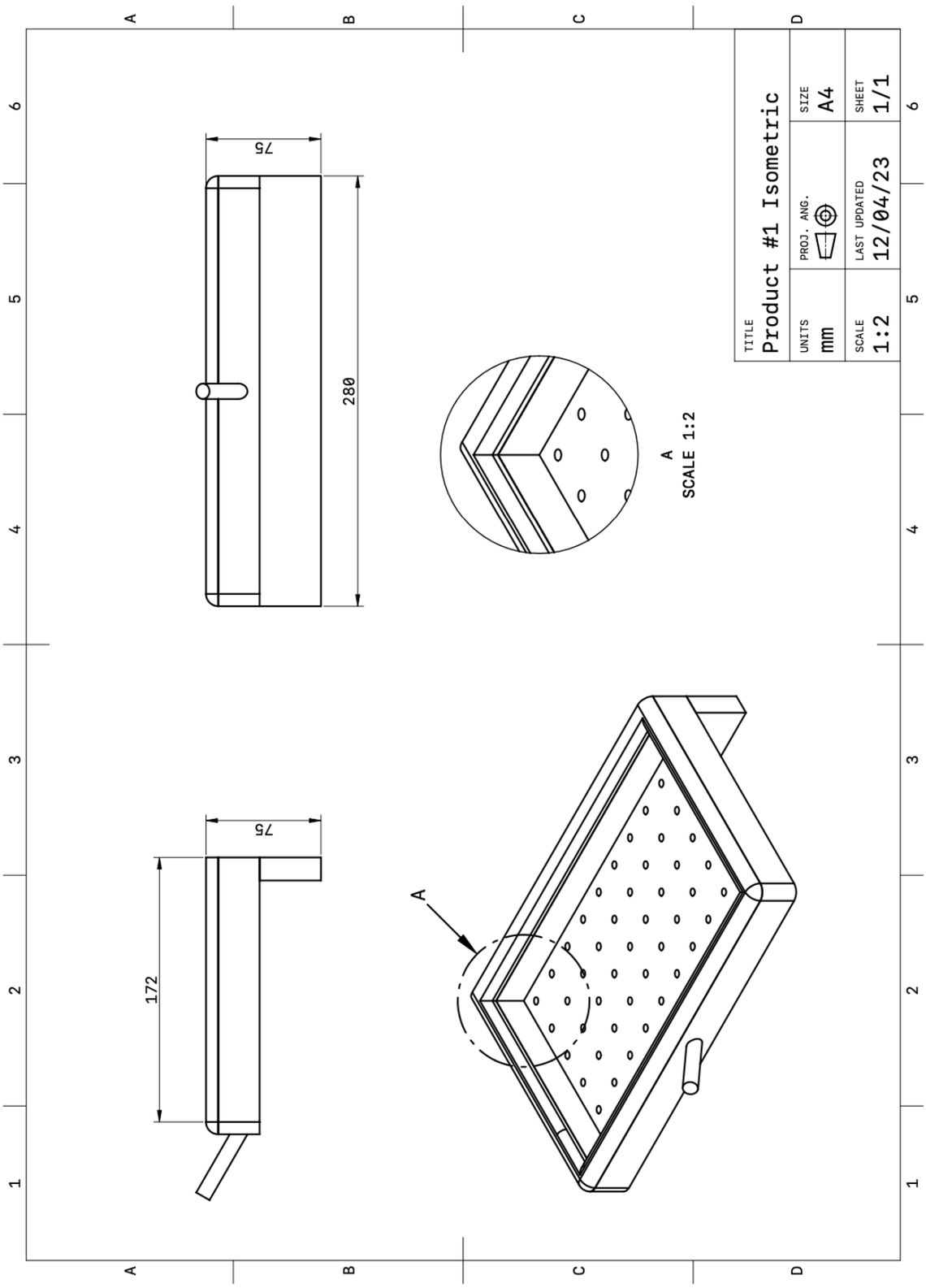
Part #	Part Name
1	Wall Piece
2	Base
3	Barrier
4	Beveled edge
5	Dowel

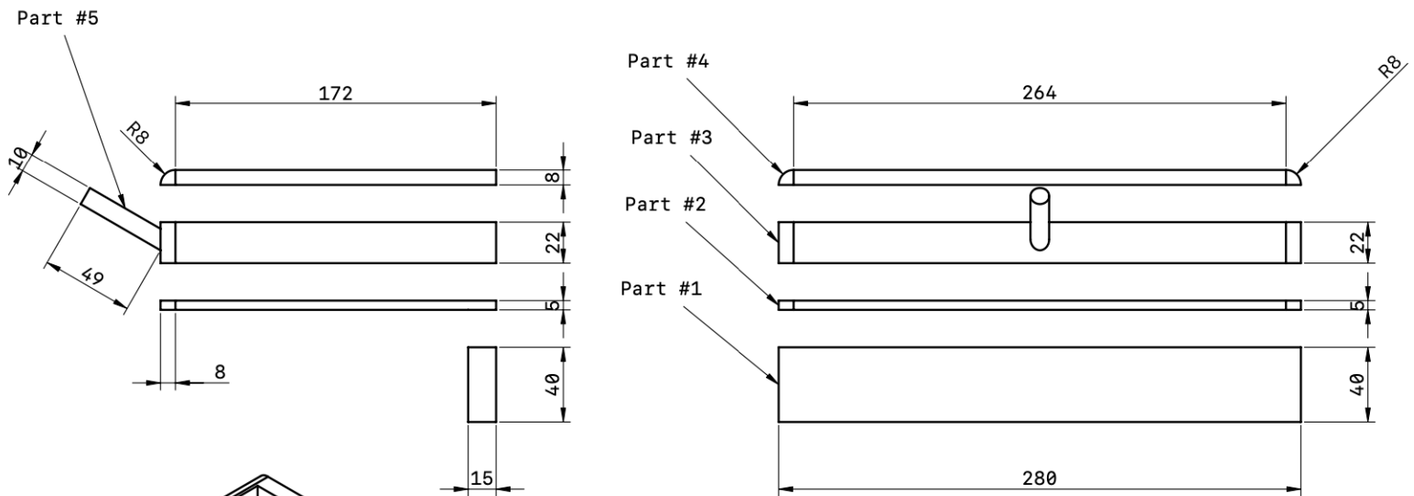
*These same parts will be produced for both product #1 and #2. The only difference will be their dimensions

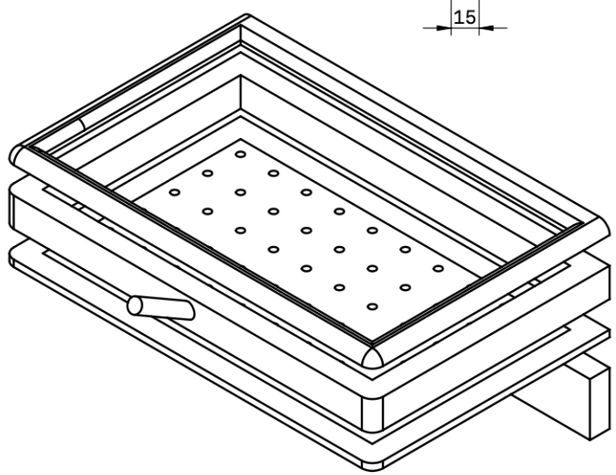
Materials	Relevant Parts	Justification
Pine wood board 	1, 2, 3	Pinewood is renewable and sustainable as it can be regrown relatively quickly and absorbs carbon dioxide in the atmosphere. It is also cheap as it is grown locally in Egypt. It is lightweight while still being having high compressive strength due to the strength of the natural fibers.
Pine wood dowel 	5	
Red Oak board 	4	Red Oak is a type of darkwood meaning it is heavy and has very high compressive strength due to its density. It's main feature however is its pleasant aesthetic appearance. However due to its density, it takes longer to grow than softwood which makes it slightly more expensive. Additionally red oak accepts stain very well.

Manufacturing Technique	**Relevant Parts**	**Justification**
Computer Numerical Control (CNC) 	2, 3, 4	CNC machining will allow the pieces to be manufactured quickly and precisely. Furthermore it will be able to bevel the edges of the parts. It can also be used to create the pattern of holes in part #2 (Specification 1.1). However, this precision and mechanical ability also means an increase in cost and energy usage, as well as the fact the CNC must be operated by a skiller laborer.
Sawing 	1, 5	Sawing, either by hand or using a band saw, will be used to cut the simple pieces such as the wall piece (#1) and the dowel (#5). This is a quick, cheap, and efficient process, though it can be imprecise and the cut edge will be rough.
Staining 	1, 2, 3, 4, 5	Given that the product will be used in the shower, all parts must be waterproofed (Specification 5.3). This will be done by staining the wood. Additionally, wood staining will increase the aesthetic appearance of the product. This however will take time to do and to dry.
Glueing 	1, 2, 3, 4, 5	All pieces will be glued together as it is the least intrusive form of joining and can handle the necessary tensile strength (Specification 4.2). This however will take time to do and to dry, and the excess glue must be removed.
Screwing 	1	The wall piece will be screwed to the shower wall as it is the easiest and strongest way to attach the product (Specification 4.1). Additionally screws are cheap and unobstrusive, and will not rust with exposure to water.
Sanding 	1, 2, 3, 4, 5	All pieces will be sanded down to ensure that there are no rough edges (Specification 4.3). This will increase safety and aesthetic appeal but will take time and must be done in a properly ventilated area.
Drilling 	1	The wall piece will have 2 holes drilled in it to allow screws to attach it to the wall (Specification 4.1). This process is quick and cheap but uses a lot of energy.

C.2 Develops an accurate design proposal in sufficient detail for a third party to manufacture the prototype.







All parts will be butt-jointed with wood glue

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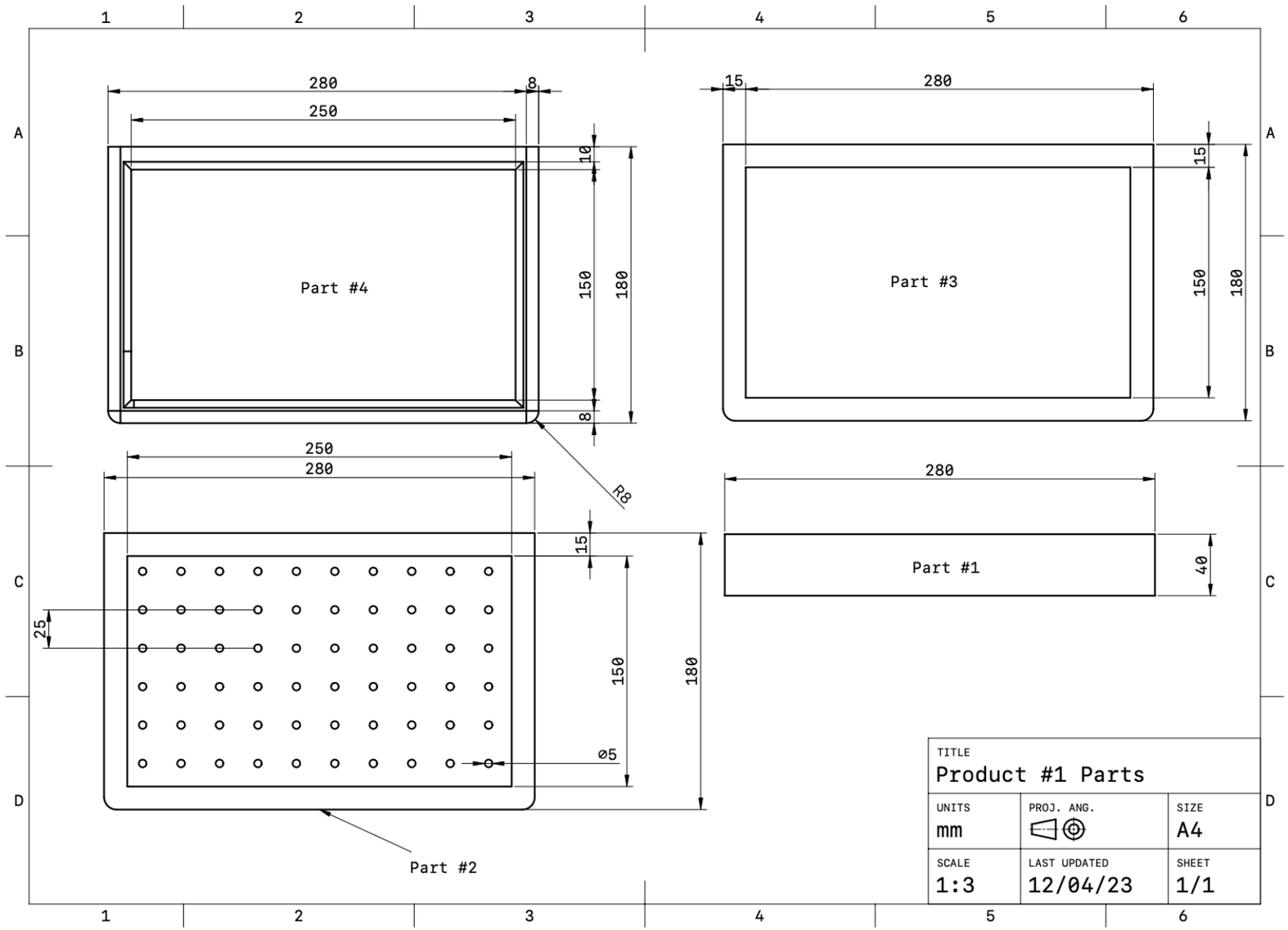
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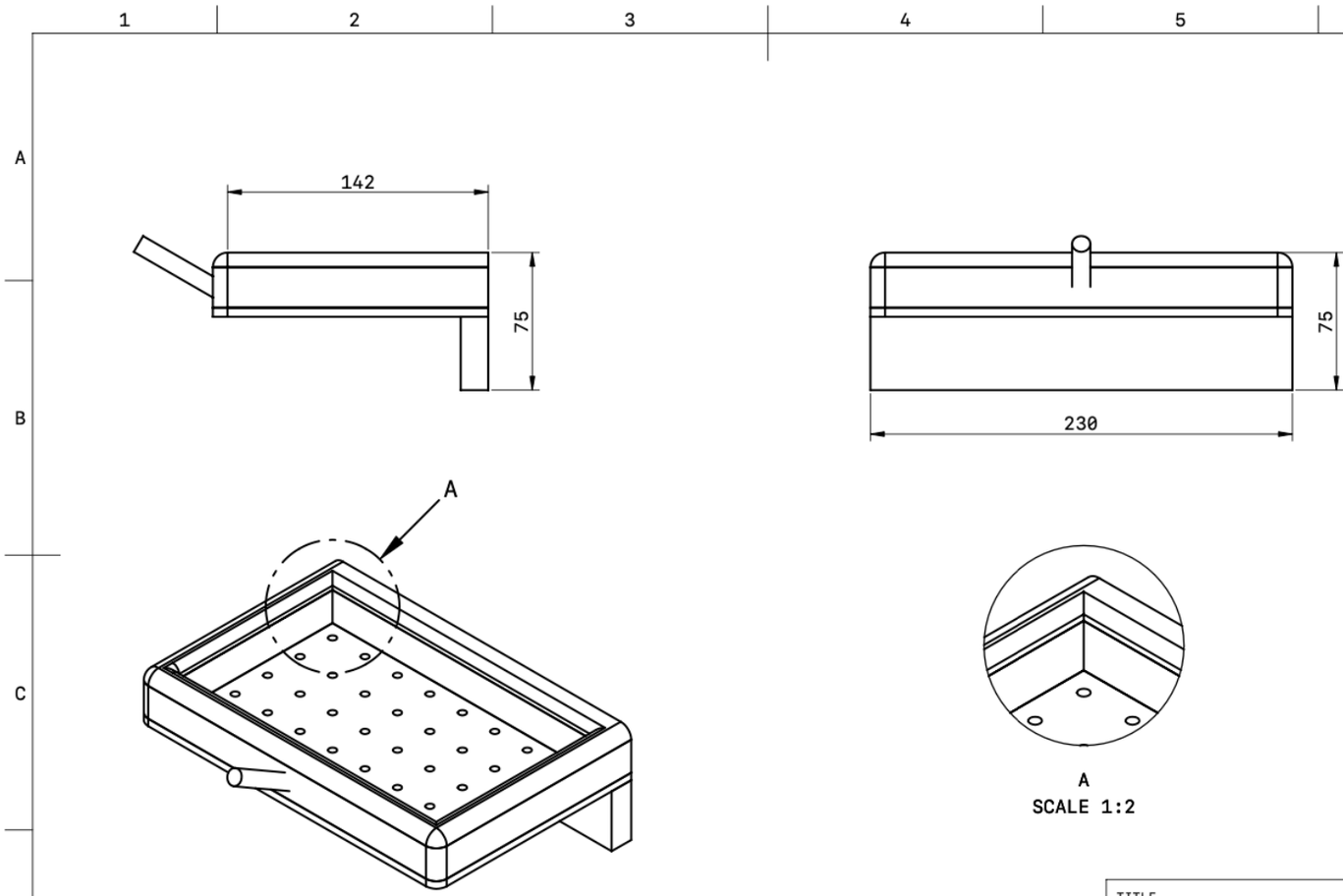

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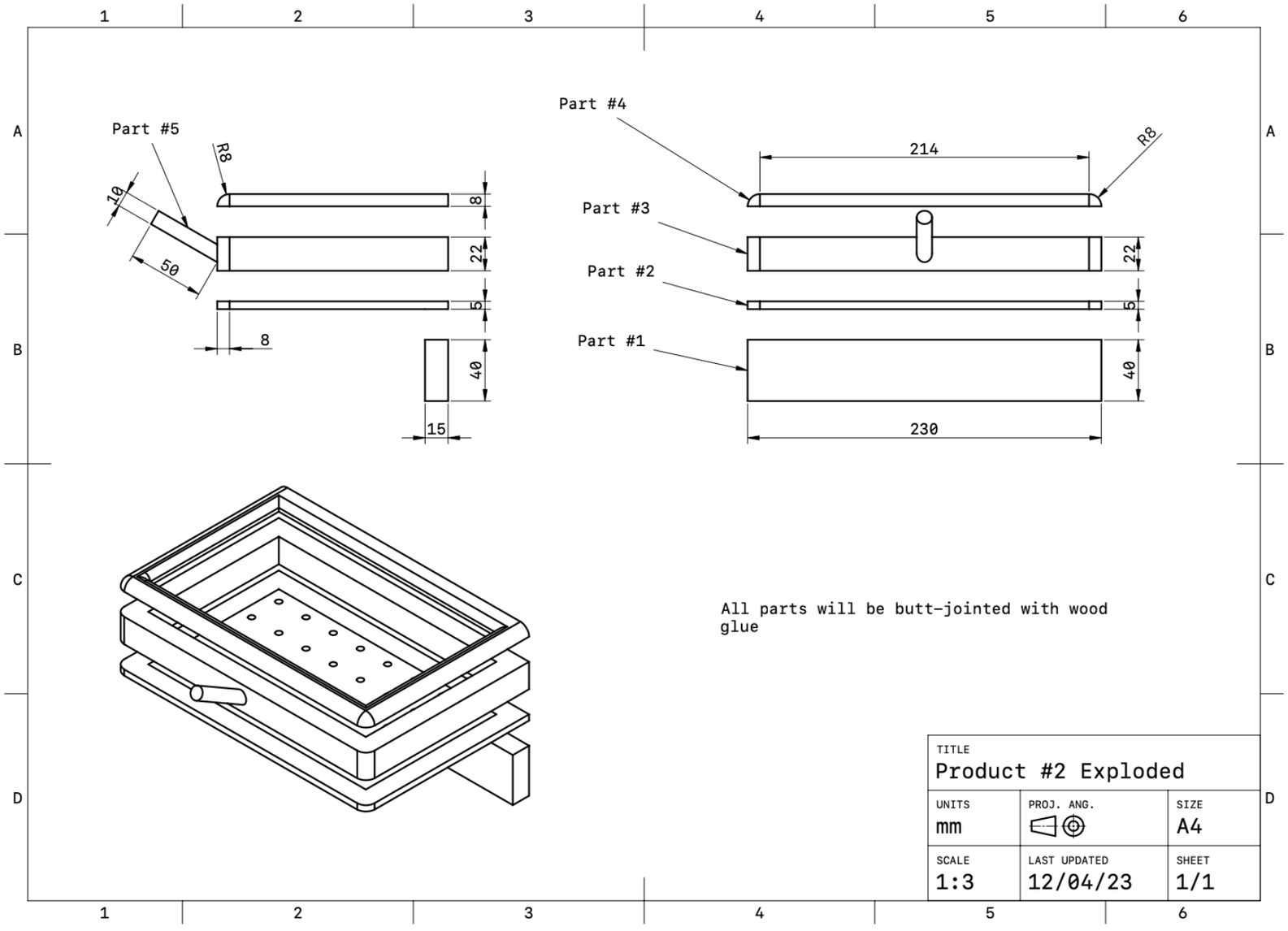
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Part #4
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Part #2
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Part #1
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All parts will be butt-jointed with wood glue
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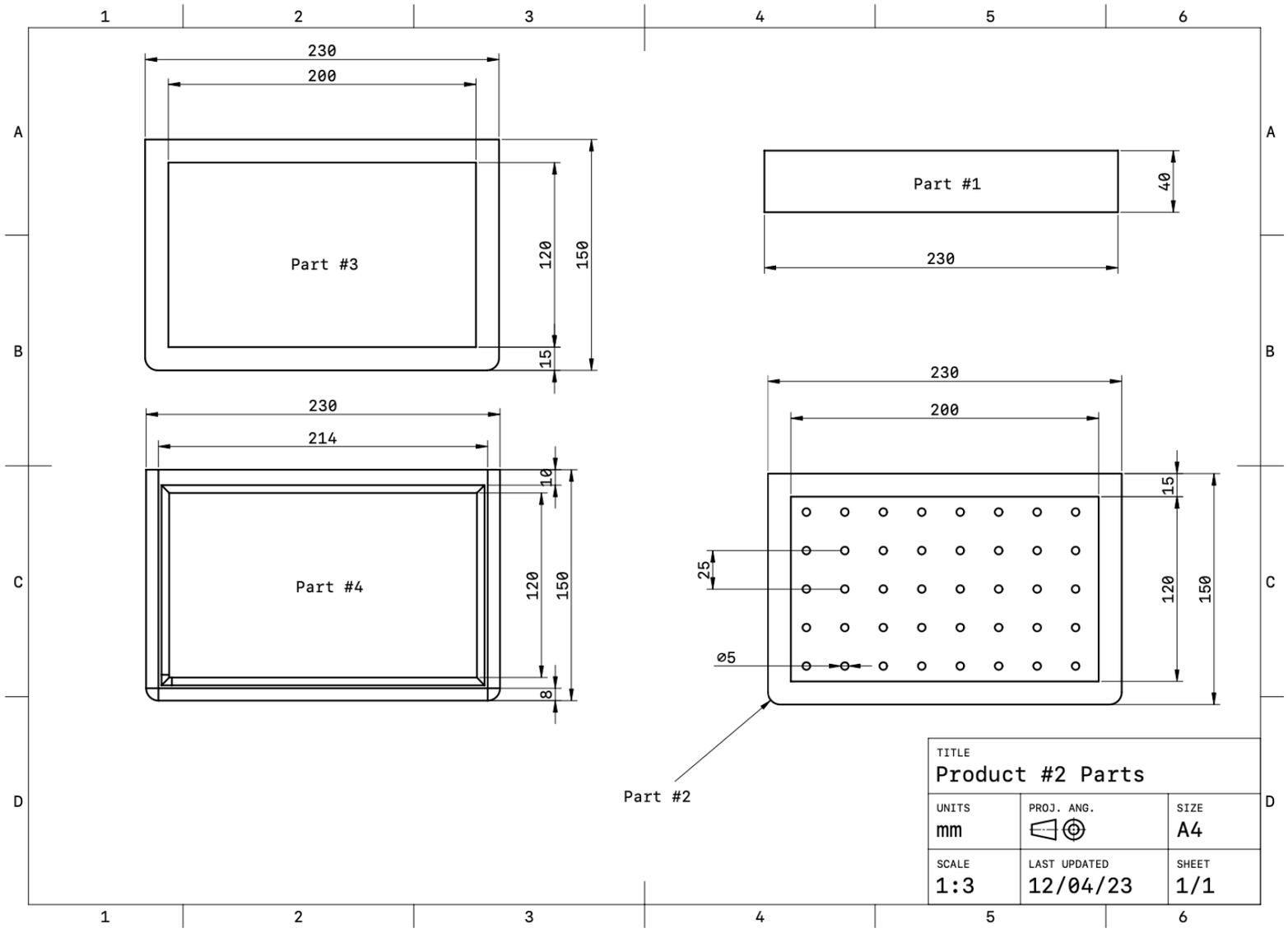
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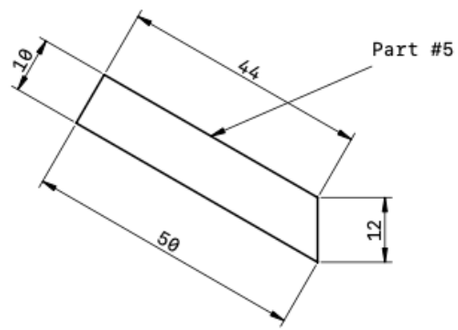
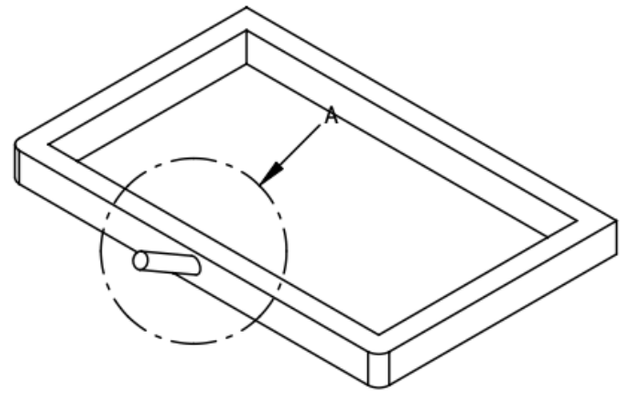
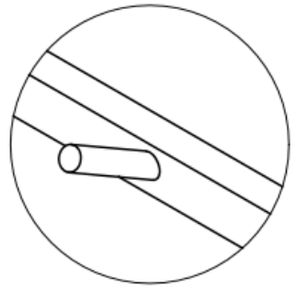




SCALE 1:3

Part will be butt jointed with wood glue



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SCALE 1:2

TITLE		
Part 5		
UNITS mm	PROJ. ANG.	SIZE A4
SCALE 1:1	LAST UPDATED 12/04/23	SHEET 1/1

C.3 Produces a detailed plan for the manufacture of the prototype

Bill of Materials:

Part #	Material	Dimensions (L x W x H) (mm)		Unit Cost ($)	Total Cost ($)
		Product #1	Product #2		
1	Pine wood board	280 x 40 x 15	230 x 40 x 15	$1	$2
2		280 x 180 x 5	230 x 150 x 5	$1.5	$3
3		280 x 180 x 22	230 x 150 x 22	$2	$4
4	Pine wood dowel	50 x 10	50 x 10	$0.5	$1
5	Red oak board	280 x 180 x 8	230 x 150 x 8	$2	$4
7	Screws (x2)	N/A	N/A	$0.05	$0.1

Construction Plan:

Step	Process	Equipment	Scheduling	Quality Conrol	Risk Assesment
1	Cut part #1	Bandsaw	5 min of measuring and 2 min of cutting	Confirm measurements with ruler	Use dust collector. Wear ear and eye protection.
2	Drill 2 holes in part #1	Drill press	2 min of measuring, 1 min of drilling, 1 min of sanding	Ensure hole is drilled through and sanded	Ensure part is clamped. Wear ear and eye protection.
3	Cut parts #2, 3, 4	CNC Machine	5 min of programming and 1 hour of cutting	Visually asses finished parts	Ensure piece is clamped down
4	Cut part #5	Handsaw	1 min of measuring and 2 min of cutting	Confirm angle and measurments	Ensure piece is clamped down. Wear hand and eye protection.
5	Sand part #5	Sandpaper	2 min of sanding	Ensure piece is smooth to the touch	Use dust collector and wear mask.
6	Glue parts #1, 2, 3, 4	Wood glue	2 min of glueing, 1 min of clamping, 24 hours of drying	Ensure all pieces are aligned and clamped together	Wear gloves
7	Clean excess glue	Tissue	2 min of cleaning	Ensure all excess glue is wiped away	
8	Sand product	Sandpaper and rotary sander	15 min of sanding	Ensure product is smooth to the touch	Use dust collector and wear mask.
9	Glue part #5 to product	Wood glue	1 min of glueing, 24 hour of drying	Ensure product is held in place until glue cures	Wear gloves
10	Clean excess glue	Tissue	1 min of cleaning	Ensure all excess glue is wiped away	
11	Stain the product	Oil based wood stain	10 min of staining, 24 hours of drying	Ensure staining is even and is not in contact with work surface	
12	Repeat steps 1-11 for Product #2				

Criterion D

D.1 Justify A Testing Strategy To Measure the Success of the Prototype

Design Spec	Summary	Test	Data	Description and Justification
1.1	A key feature of the design is that it allows water to pass through to prevent the accumulation of mold and bacteria.	Lab Test	Qualitative	This can be tested in the lab by spraying water on the design and measuring if all of it passes through and how long it takes. This is the best way to test this as it will simulate shower conditions.
2.1	The height and placement of the designs are important so that they are easily accessible by both clients.	Usability Test Performance Test	Qualitative	The design will be tested to check if it is within comfortable arm's reach of my clients. This is the best way to test this as I can see if there are any issues with the placement of the design.
2.2	The design should have a usable surface area of 450 cm^2. This will ensure that there is enough space for all products.	Lab Test Performance Test	Quantitative	Measure the product and calculate the surface area. Also, test with actual products to check that there is enough space. These are both good ways to test this as they are simple and accurate.
4.1/4.2	The designs must be able to support 2 kg as this is the weight of all the products.	Performance Test Durability Test	Quantitative	A weight will be attached to the design to ensure it can stay attached to the wall. This is the best way to test it as it will reveal any issues related to strength that might not show up using FEA.
4.3	The design will have a smooth texture with no sharp corners.	Expert Appraisal	Qualitative	An expert can determine if the design is smooth enough and ensure it does not have sharp corners.
5.3	The design must be protected from water so that it does not corrode or damage.	Lab Testing	Qualitative	The designs will be submerged in water for an extended period of time to ensure that they are adequately water-protected. Since the timeframe is longer and the product will be submerged, this will reveal if any parts are not water-protected that did not show up in previous tests.
5.3		Performance Test	Qualitative	Use the product for one day in the shower to ensure it is adequately water-protected. Since the timeframe is longer, this will reveal if any parts are not water-protected that did not show up in previous tests.
N/A		Life Cycle Analysis	Quantitative	An Environmental Assessment Matrix will be used to analyze the environmental impact of the design at each stage throughout its life cycle. This is the best way to quantify and measure the environmental impact of the product.

D.2 Evaluates the Success of the Prototype Against the Design Specification

Design Spec	Results	Analysis	Evaluation
1.1	Figure 24	Lab testing has revealed that most of the water can easily flow out of the product which prevents the accumulation of mold and bacteria. A significant amount of water however stays in the design which is a health issue and may also cause water damage.	Partially meets
2.1	N/A	The height and placement of the designs were done correctly so that the products were easily accessible by my clients. The products were also measured to be the correct size to accommodate all products.	Meets
2.2	Figures 25 and 26	Calculations show that both models have less than 450 cm^2 of usable surface area. Despite this, Figure 26 shows that there is indeed enough space to accommodate all products.	Partially Meets
3.1/3.2	Client interview (see appendix)	The product has a simple design and color scheme which is what my clients wanted as indicated in the client interview. It however is not “white, grey, or black” and is instead brown.	Partially meets
4.1/4.2	Figure 27	Performance testing shows that the designs can support 2 kg of weight, indicating they are strong enough to be safely used by my clients.	Meets
4.3	Expert Appraisal (see appendix)	Expert agreed that the product is smooth enough and has no sharp corners.	Meets
5.3	Figure 28	Lab testing showed that the designs handled submersion under water for an extended period of time without water damage,	Meets
6.3	Expert Appraisal (see appendix)	According to expert appraisal, the designs are within the price range of 1000 egp as the total material cost is far lower.	Meets

Figure 24. Water Flow Testing

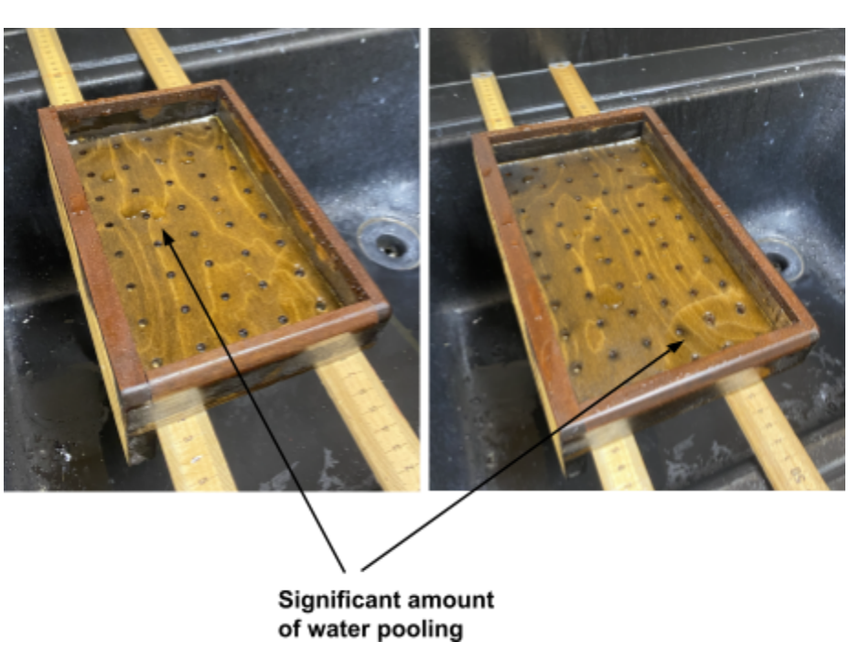


Figure 25. Surface Area Calculations

Design 1	Design 2
Area = Length X Width	Area = Length X Width
Area = 25 cm X 15 cm	Area = 20 cm X 12 cm
Area = 375 cm^2	Area = 240 cm^2

Figure 26. Products in Use

Figure 27. Weight Test

Figure 28. Submersion Test

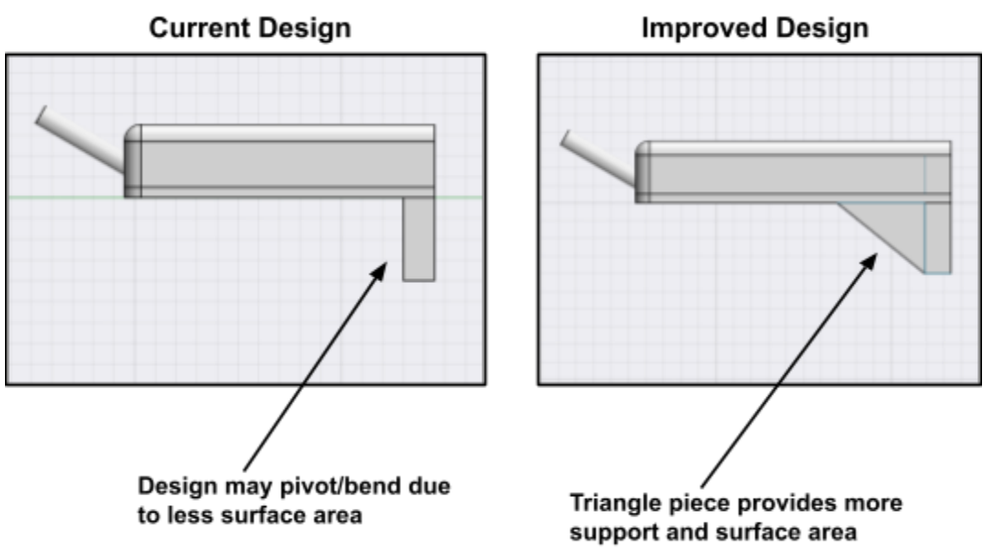
Evaluation:

In short, product testing and evaluation show that the designs have mostly met the specification. The products' safety and usability were fully met while the function and features, aesthetics, and material and production constraints were partially met. Nonetheless, my clients are still satisfied with the design as has been demonstrated by the performance and usability tests. It is clear that the parts of the specification that were not met by the final design had a minimal negative impact, or even a positive one on the satisfaction of the clients. For example, even though the specification stated that the design would be made out of only pine wood, using mahogany in the final design actually made the product more aesthetically pleasing. Likewise, while the specification stated that the design would be professionally manufactured, creating the design in the design technology lab was not a major issue as it only took slightly longer and the difference in the final quality is insignificant.

D3. Demonstrates How the Prototype Could Be Improved, Conserving How Individual Improvements Affect the Design as a Whole

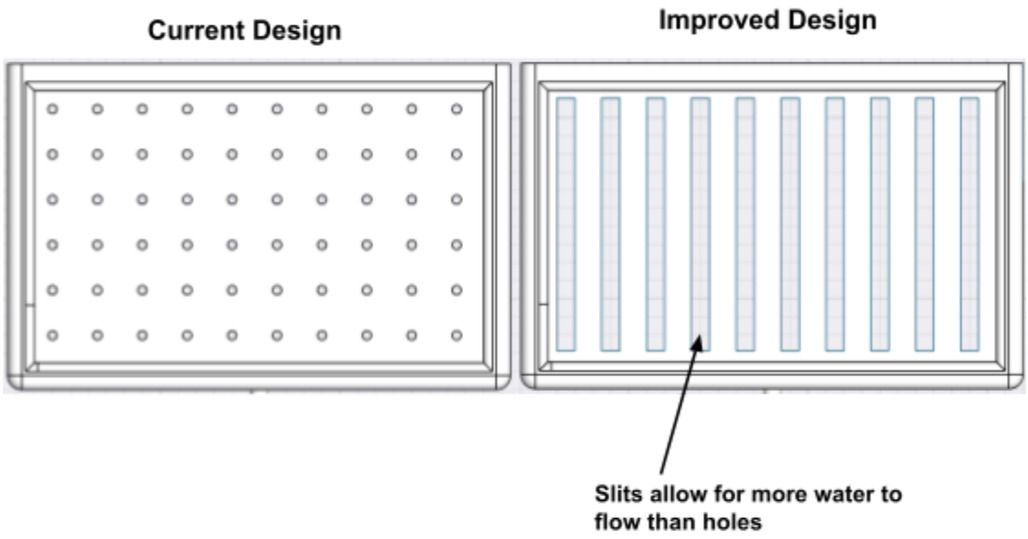
Improvement 1:

Reinforcing the wall piece will add more support to the design which will prevent any chance of it breaking under the weight of the products. Furthermore, the increased surface area means additional screws can be used to join the design to the shower wall if there is a risk of the product becoming unattached. This improvement will slightly increase the weight and cost of the product, as a result of the extra wood. It will also slightly increase production time as it will take more time to cut, glue, and finish the extra piece.



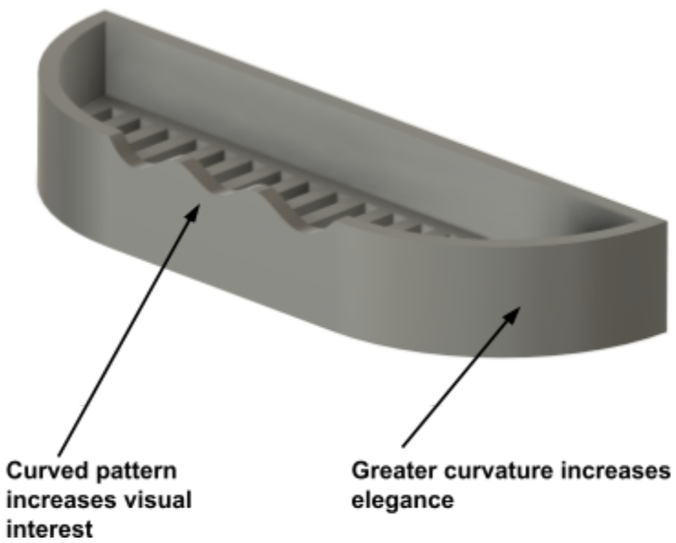
Improvement 2:

Improving the drainage system of the design is essential as lab testing has revealed that a significant amount of water stays in the design. This is an issue as it can cause bacteria, mold, and dirt to build up. This can be improved by using large slits instead of small holes, as the slits will allow more water to flow through without compromising the strength of the design. This would reduce the weight and materials and would not significantly affect the production time as cutting the slits is similar to cutting the holes.



Improvement 3:

Adopting a more elegant and rounded design would increase the aesthetic appeal of the design. The current design is very simple and "boxy" which makes it feel more obstructive while in use. A more rounded design as shown below however would make the design less intrusive and more pleasant to look at and use, therefore increasing the physiopleasure of the design.



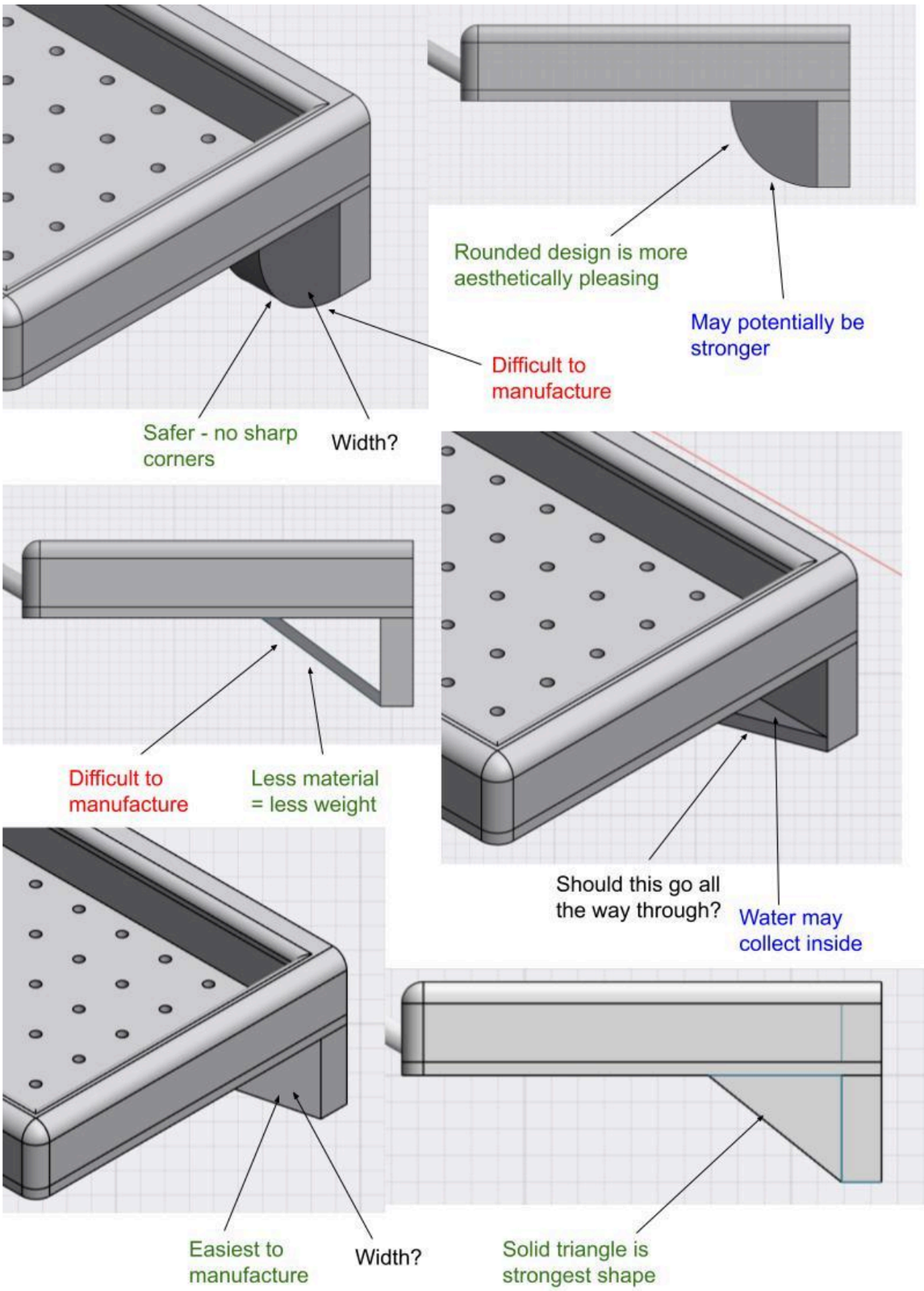
Improvement 4:

Manufacturing the design out of only 2 pieces of wood instead of 4 or 5 pieces would decrease waste and the time to produce and increase the strength of the design. While I initially planned to do this, I was not able to as I did not have access to a CNC machine. If I did, the entire main frame of the design could be cut out of a single piece of wood, and the bottom support piece could be cut as another. This would require less time to glue all parts together and would also decrease the amount of wasted material. It would also increase the strength of the design as there would only be one part where the pieces may split, compared to 4, though the likelihood of the design as a whole breaking is very low in either case.

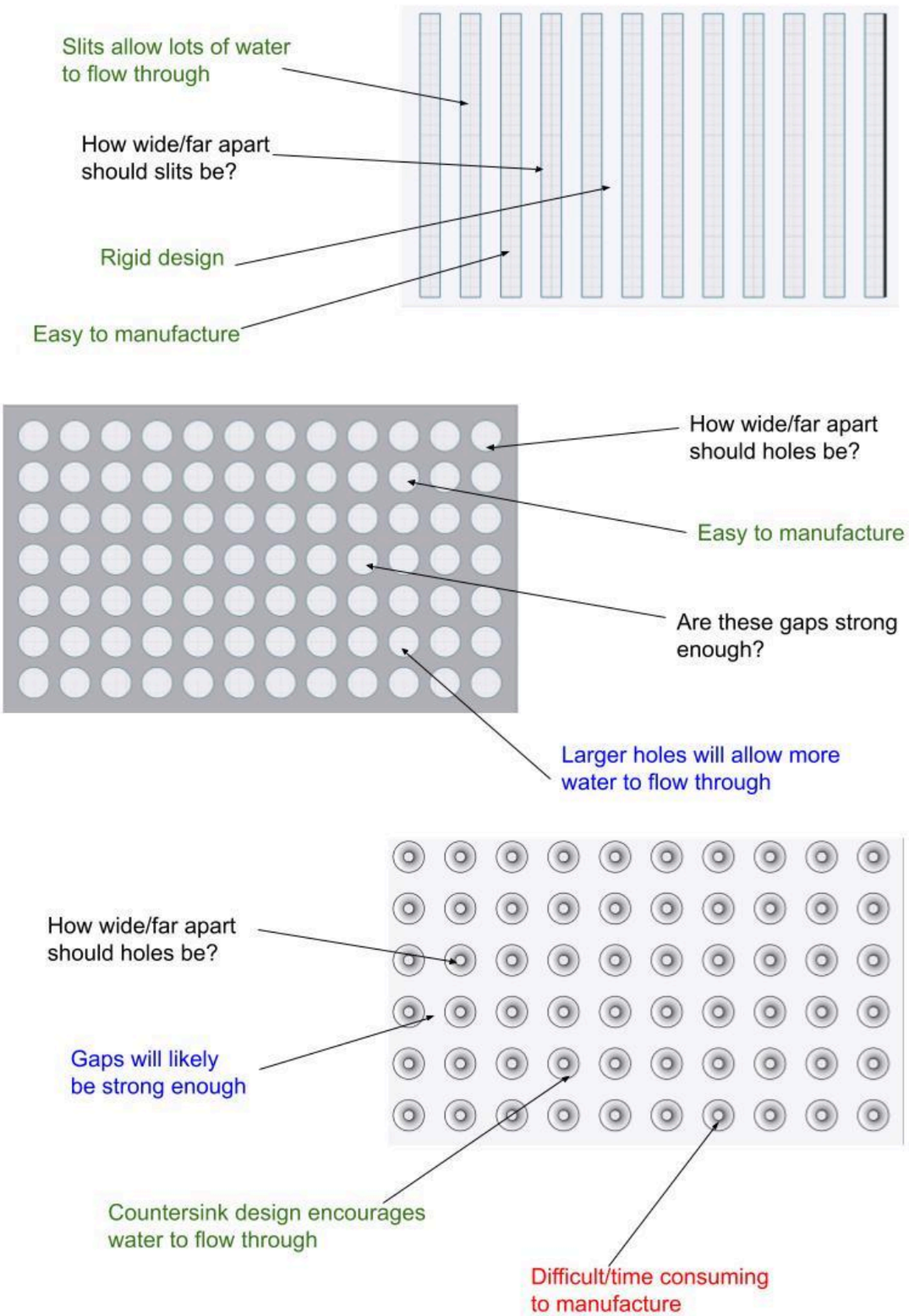
Criterion E

E1. Develop the Design, Addressing the Required Modifications for a Commercially Viable Production Process

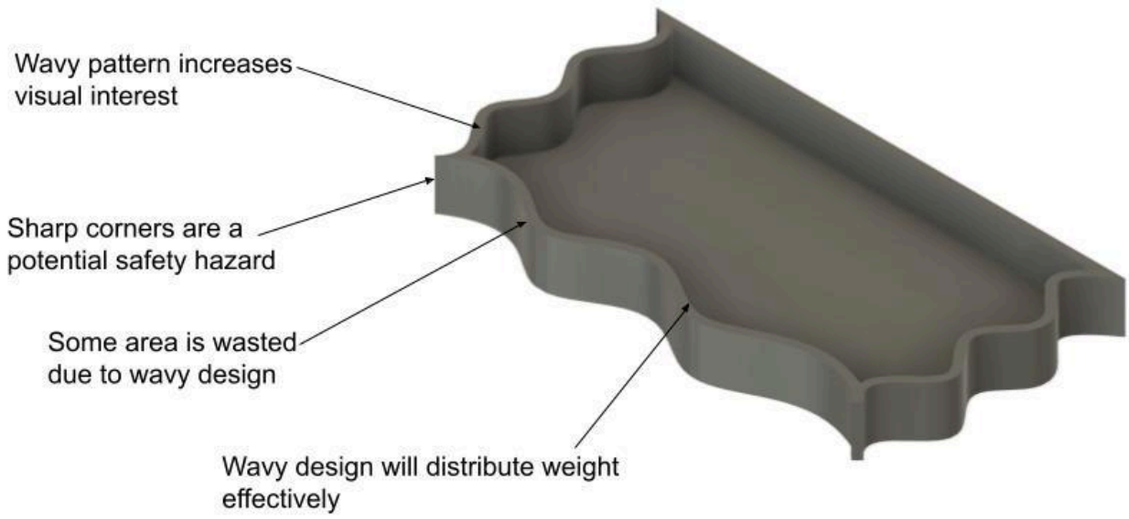
Improvement 1:

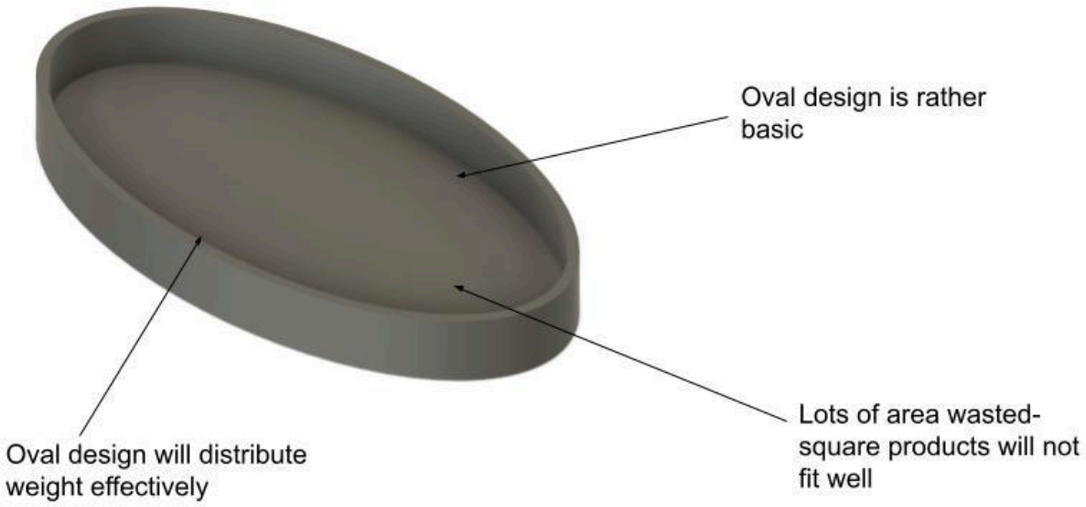


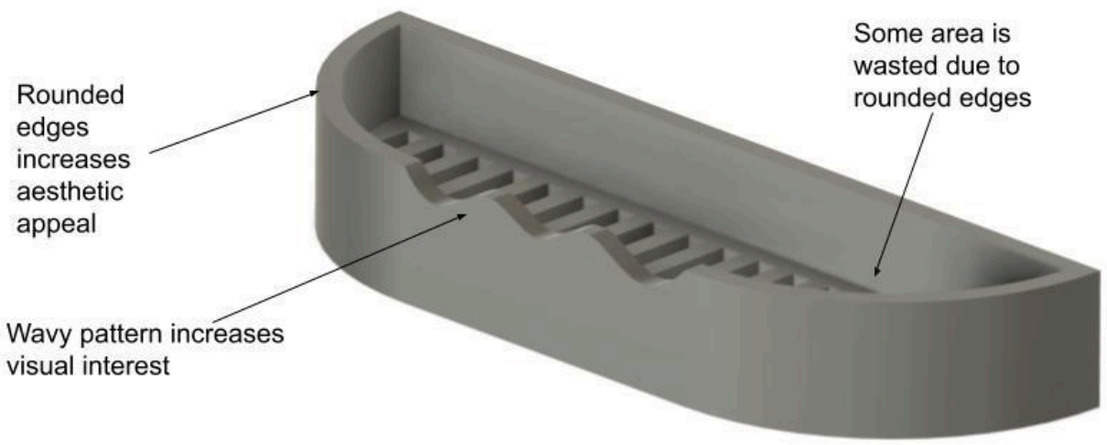
Improvement 2:



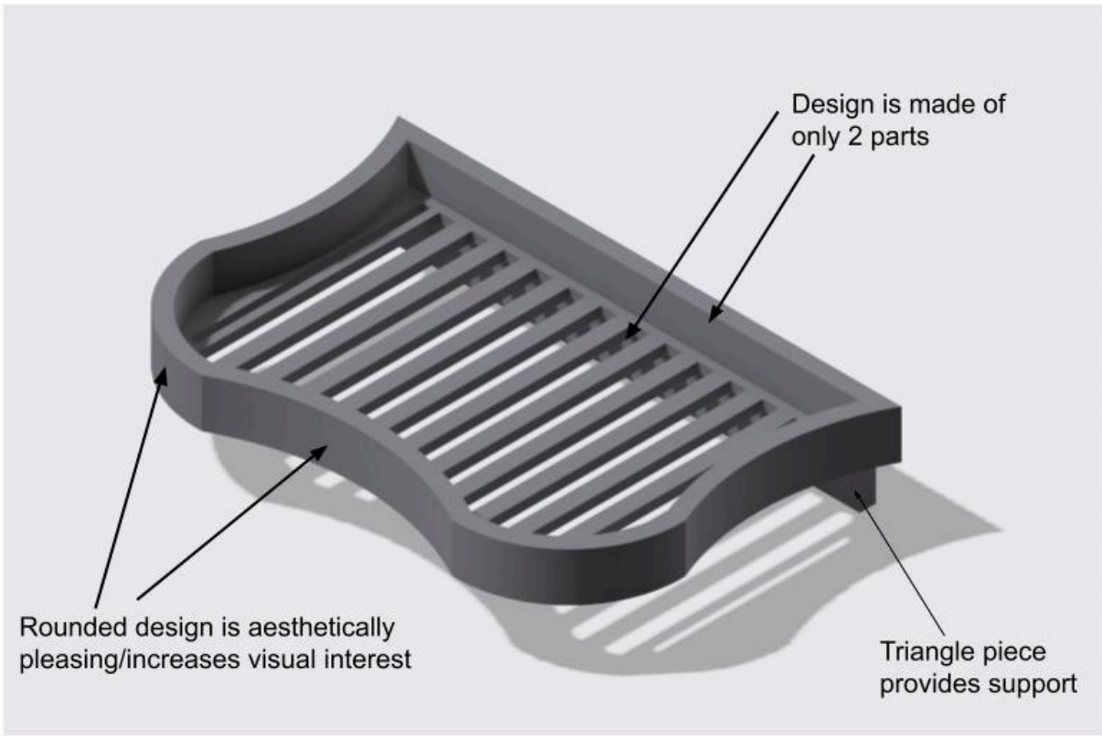
Improvement 3:

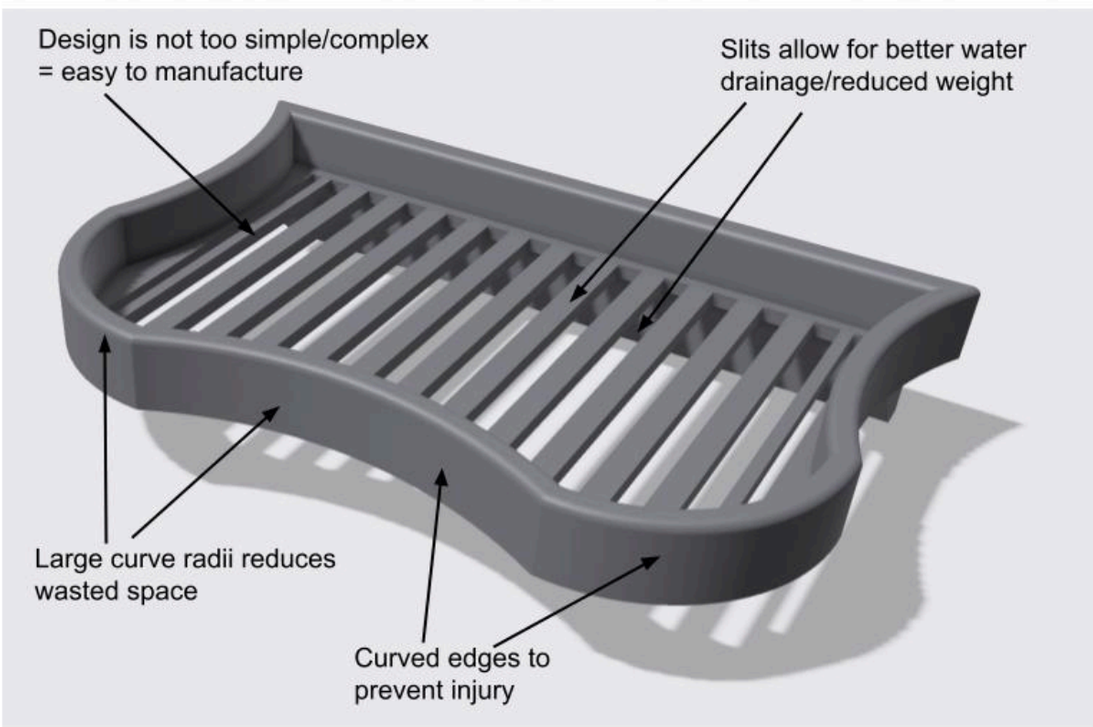


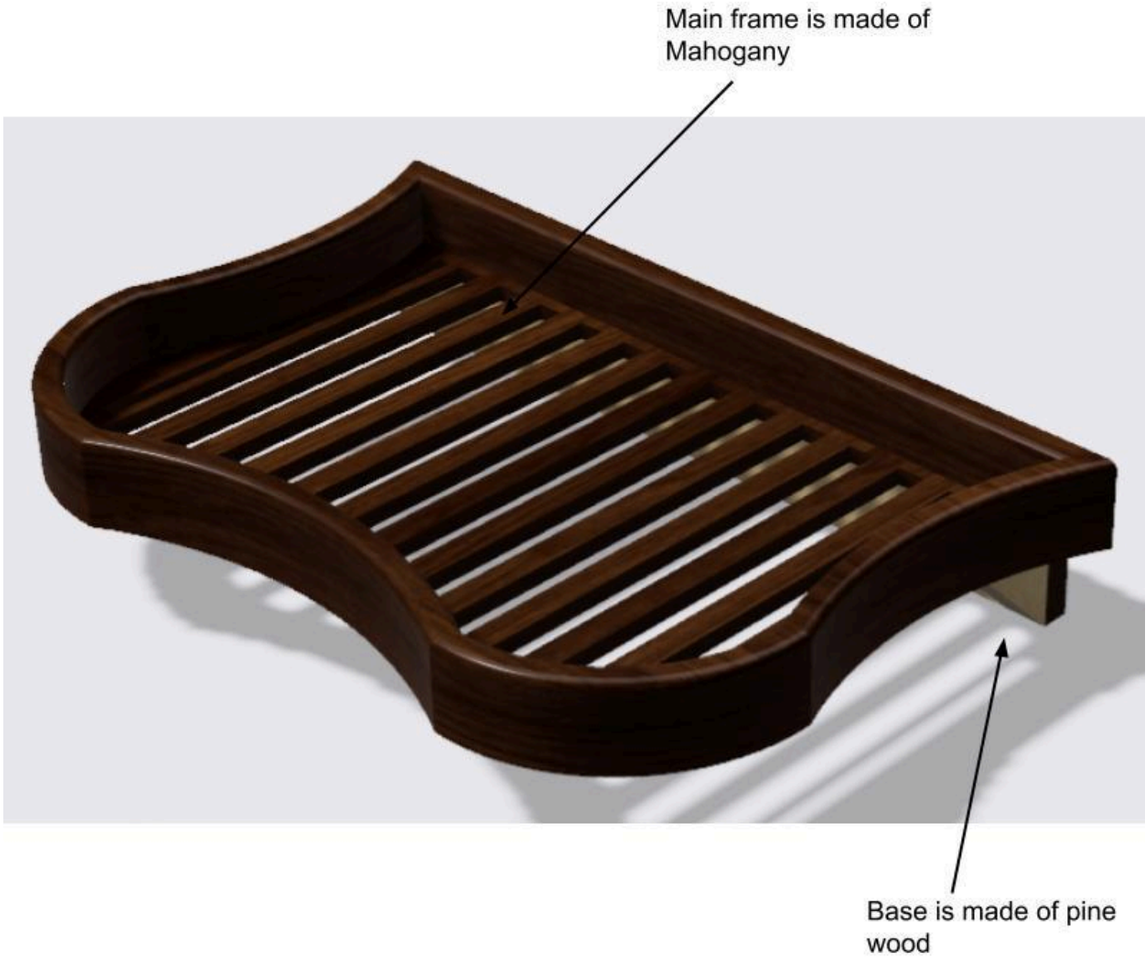


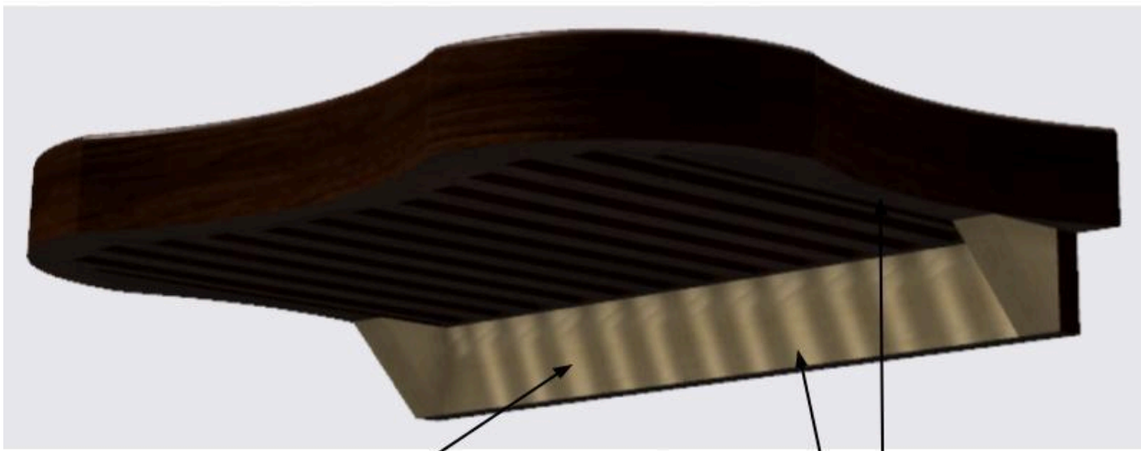


E.2 Present the Developed Commercial Product Comprehensively

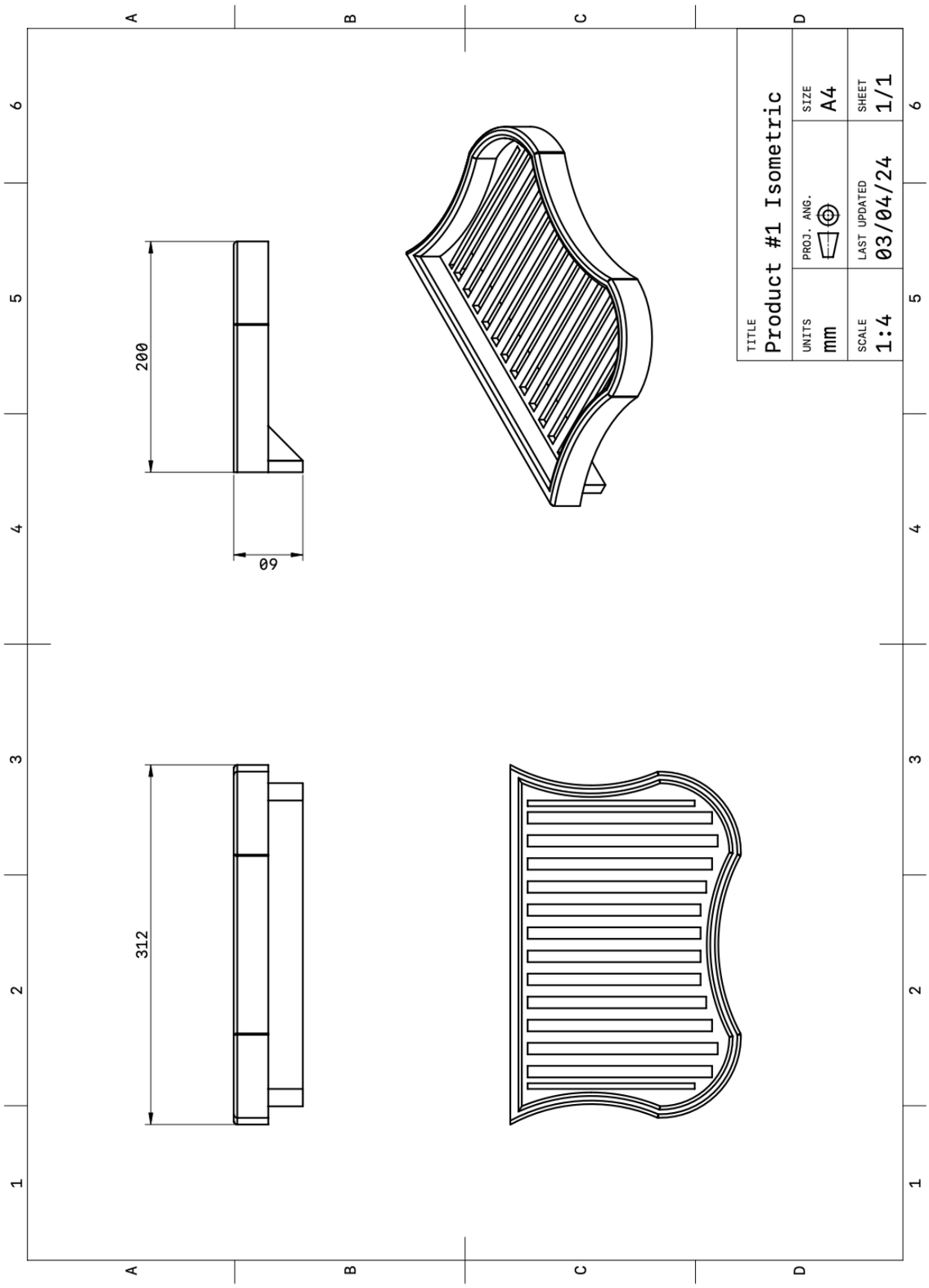


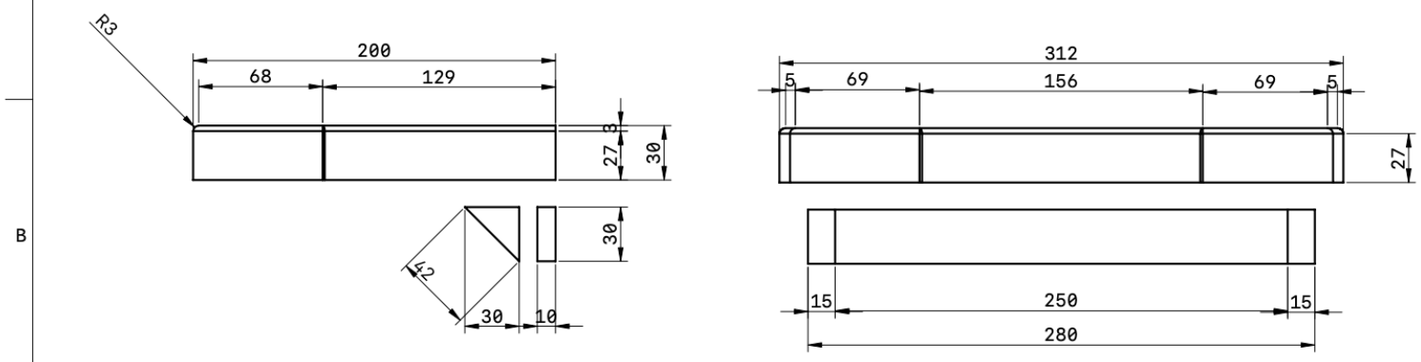


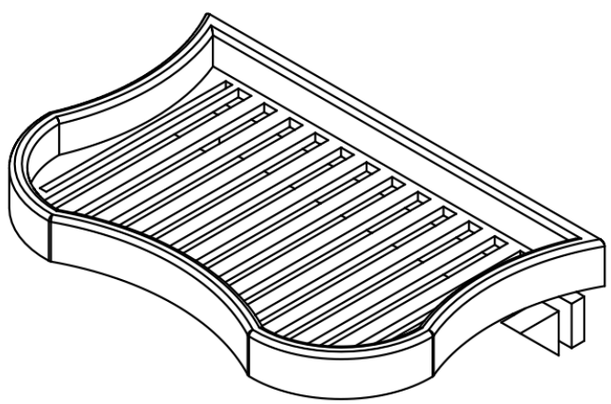

Main frame is made of Mahogany
Base is made of pine wood


Pine wood base reduces weight and cost
Different materials = increased aesthetic appeal

E3. Develop an Accurate Design Proposal of the Commercial Product in Sufficient Detail for a Third Party to Manufacture the Product







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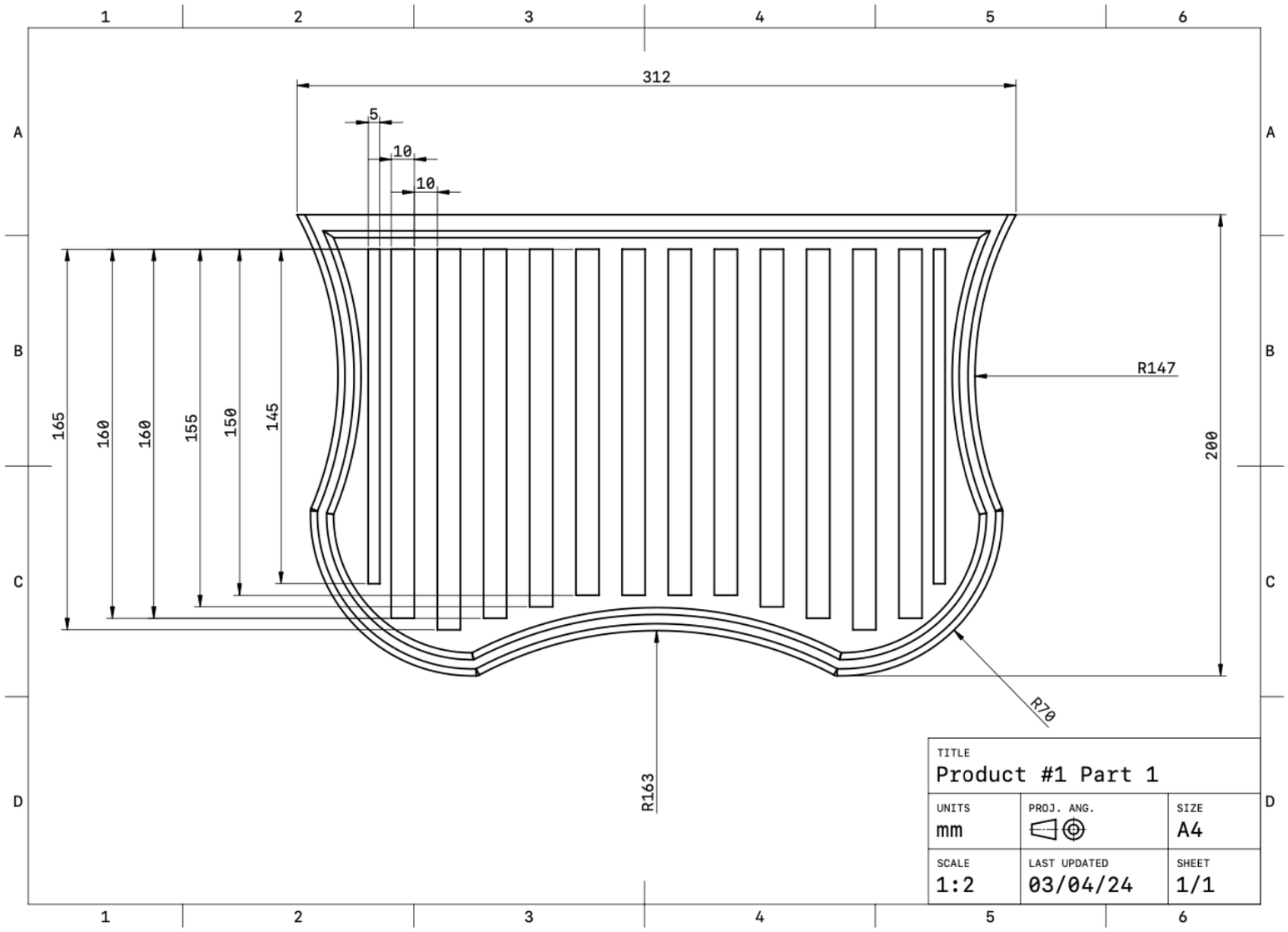
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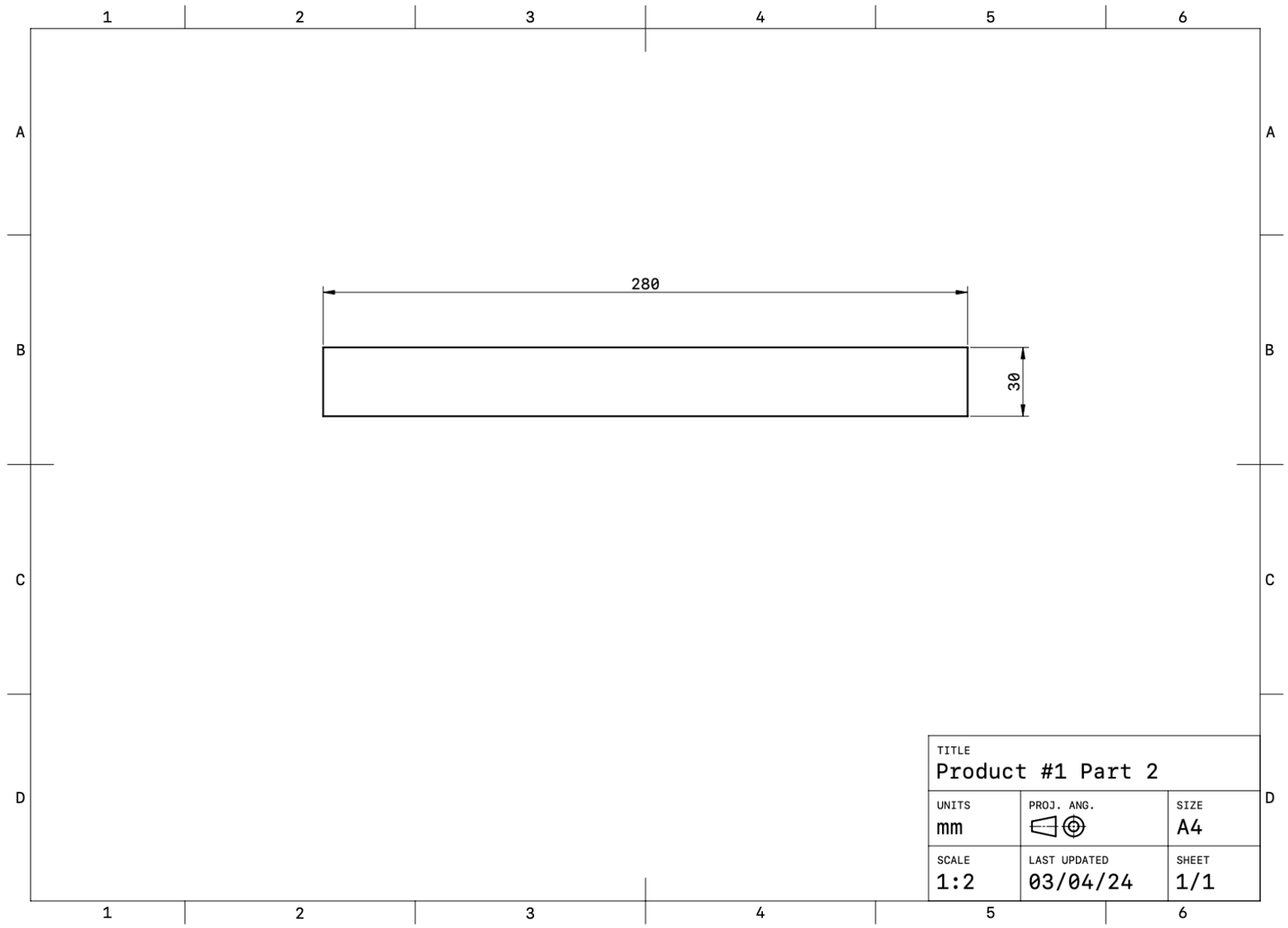
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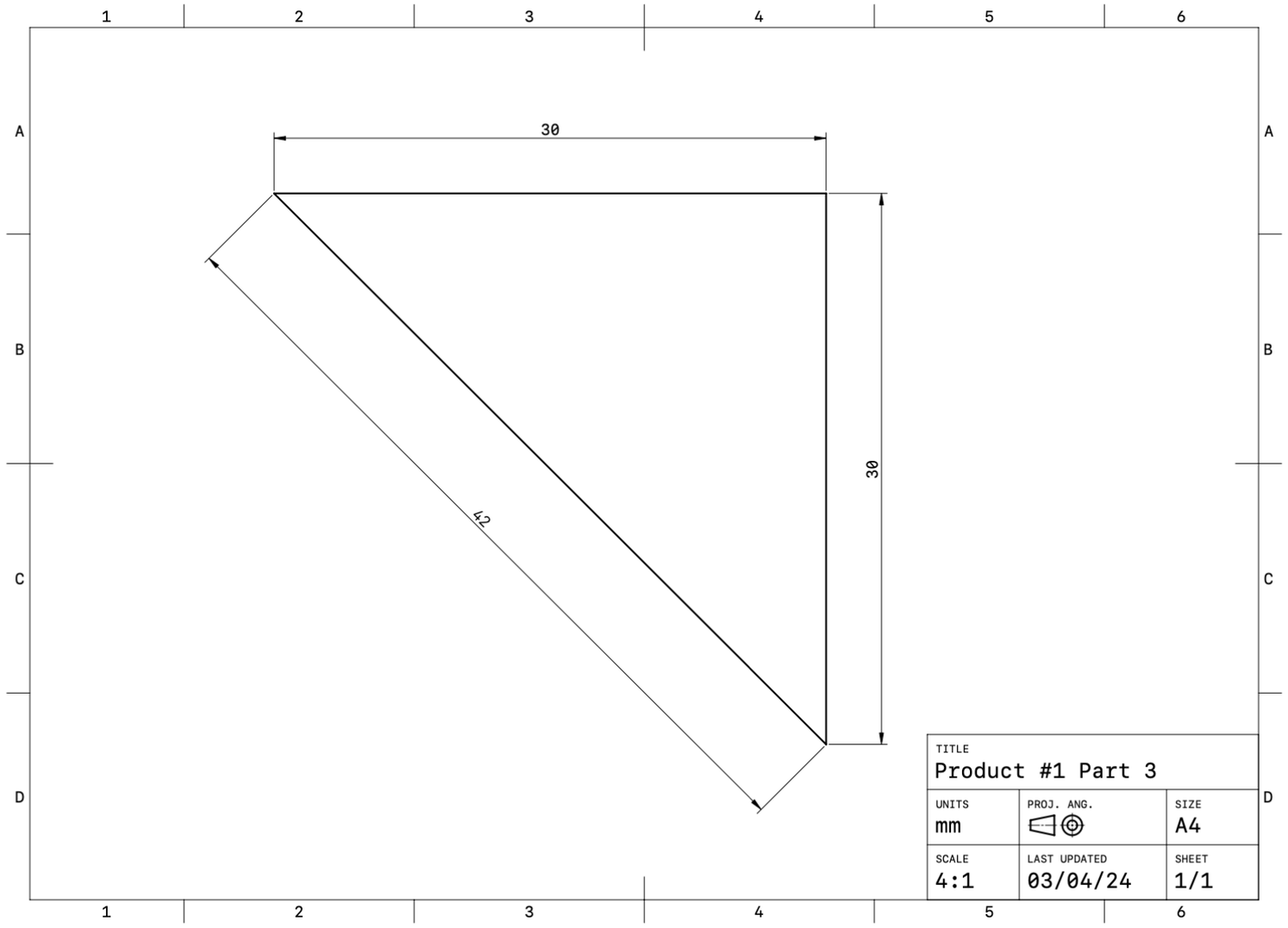
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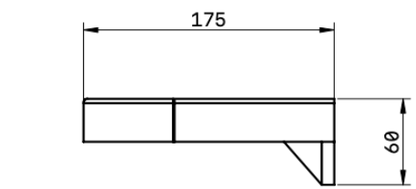

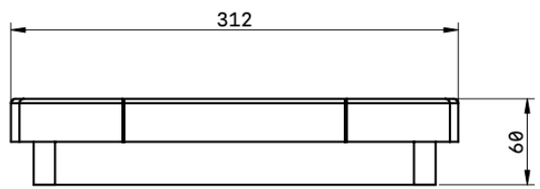

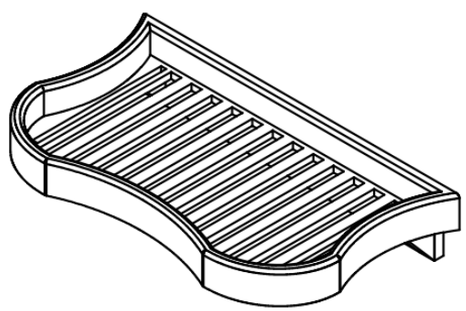

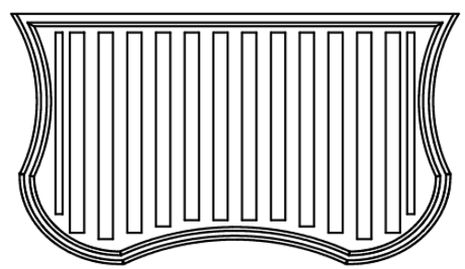

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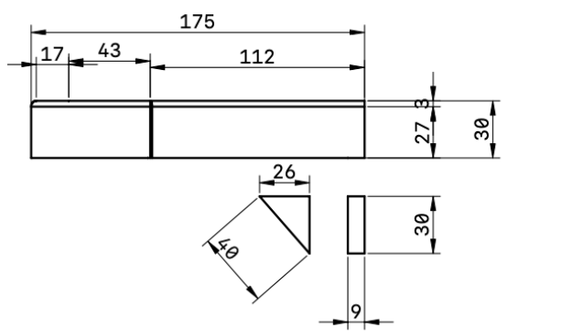

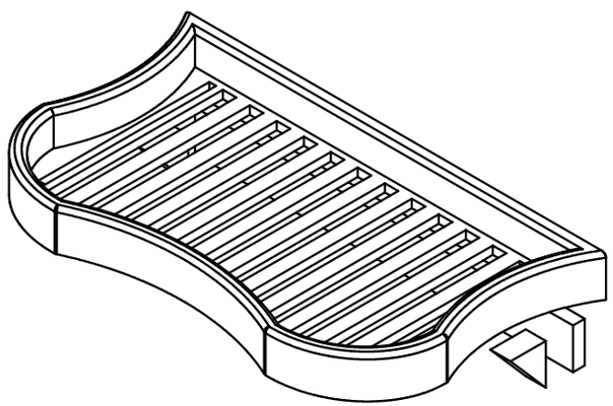

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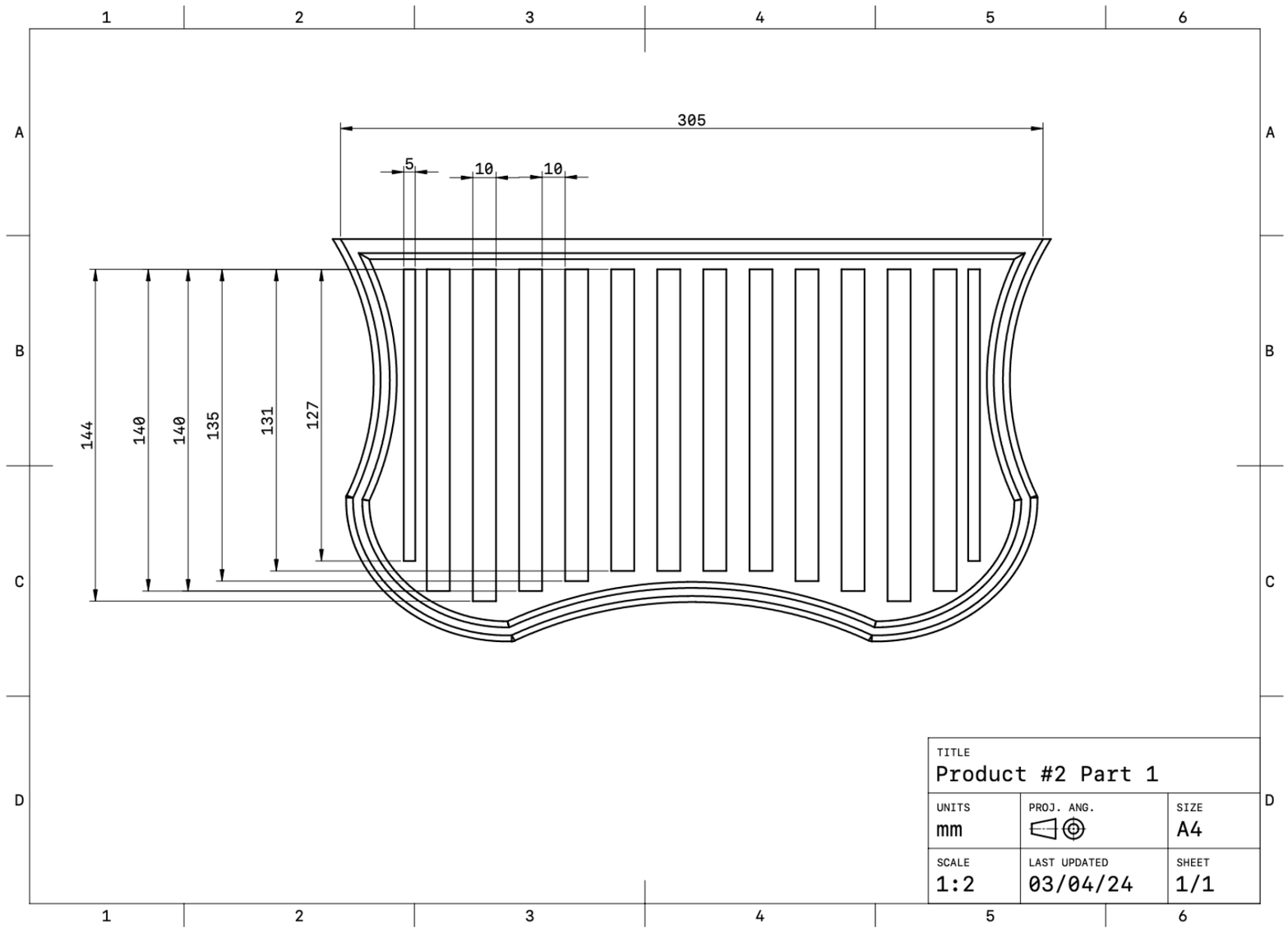
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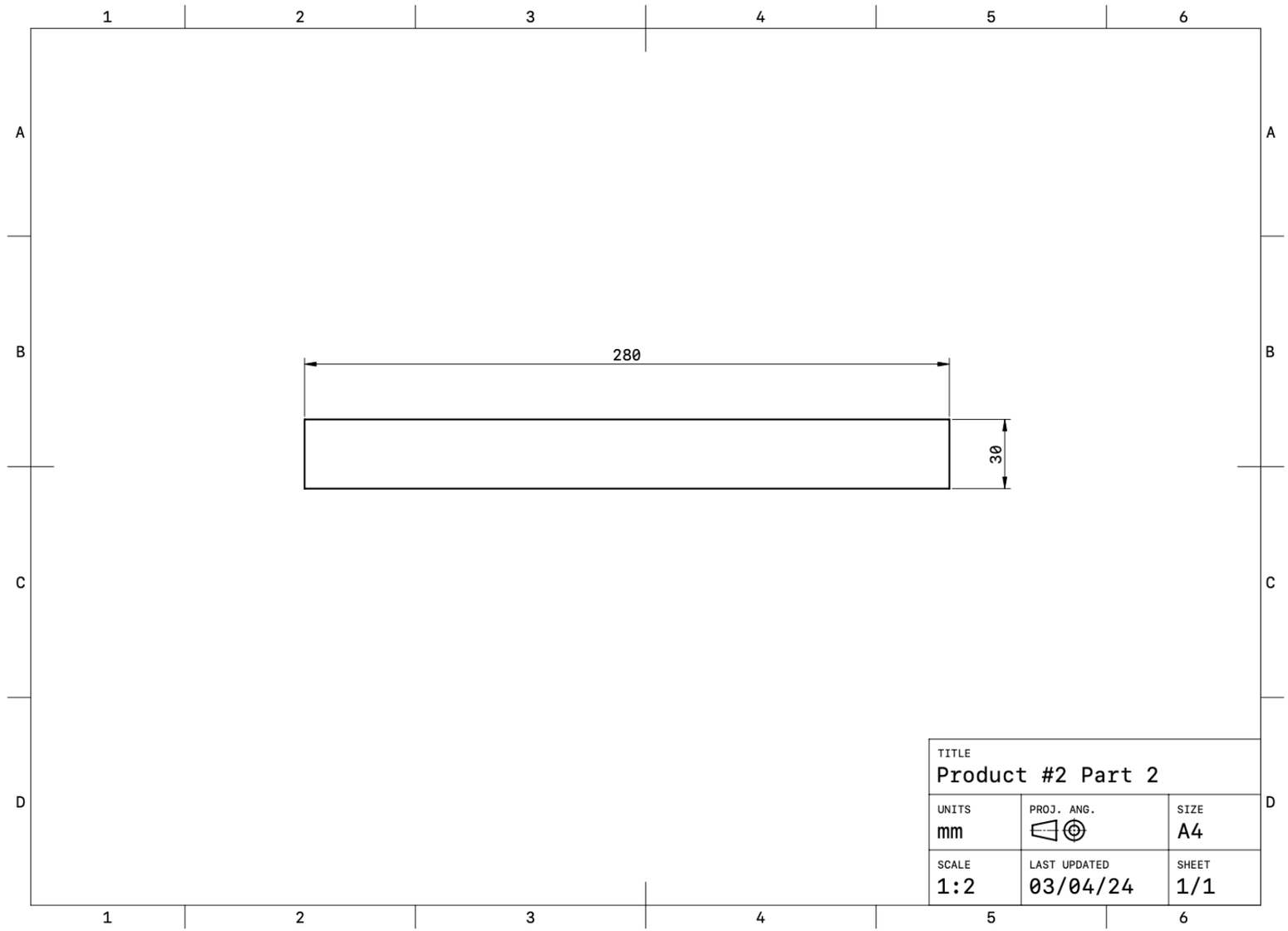
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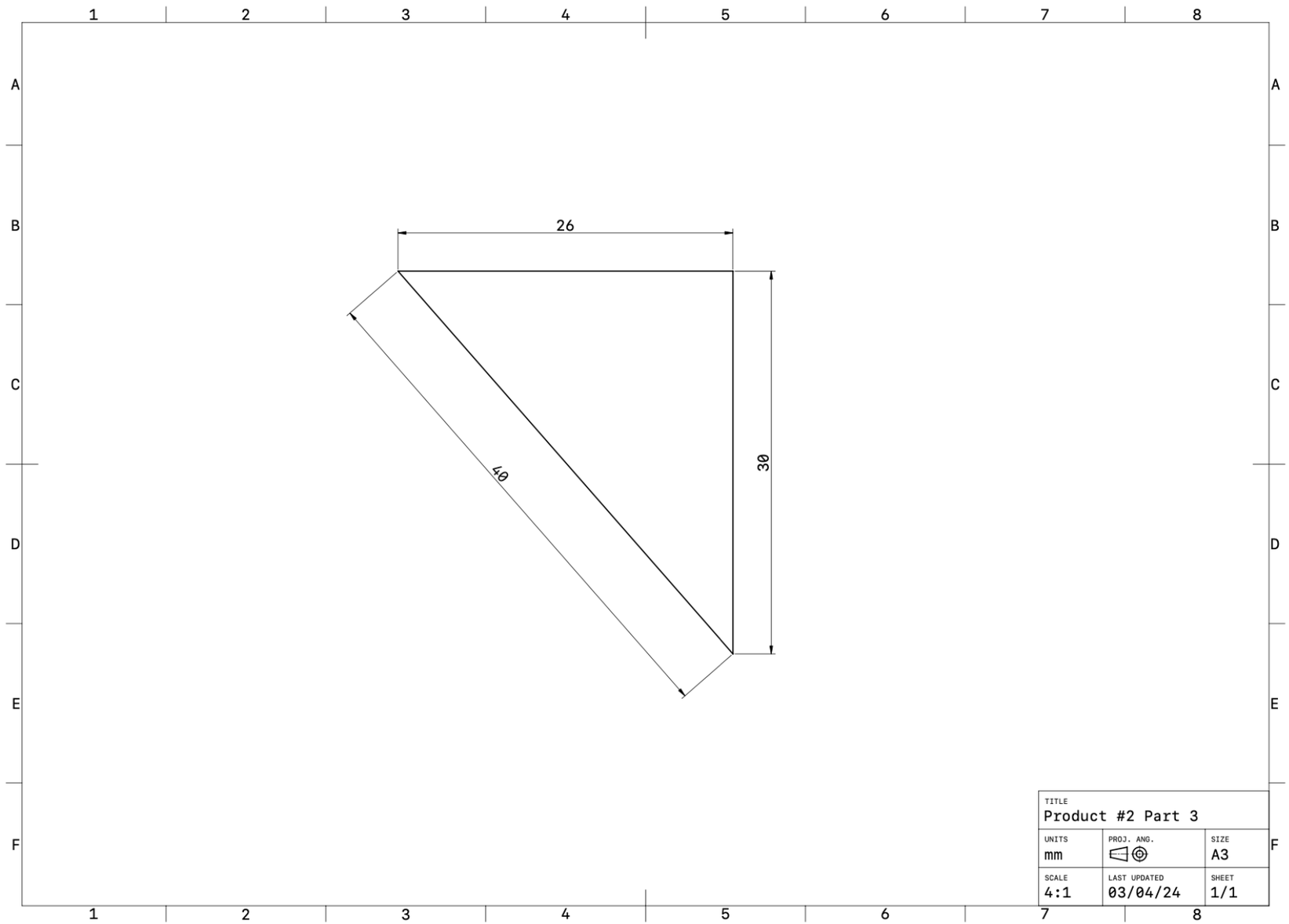

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Updated Bill of Materials:

Part #	Quantity (Per Product)	Material	Dimensions (L x W x H) (mm)		Unit Cost (Per Product) ($)	Total Cost (Per Product) ($)
			Product #1	Product #2		
1	1	Mahogany	312 x 200 x 30	305 x 160 x 30	$10	$10
2	1	Pine Wood	280 x 30 x 10	280 x 30 x 9	$10	$10
3	2		30 x 30 x 15	26 x 30 x 15	$10	$10
4	2	Screws	N/A	N/A	$0.05	$0.1
5	2	Plastic Fisher	N/A	N/A	$0.05	$0.1

Criterion F

F1. Justify the Choice of Materials and Components Appropriate for Commercial Production

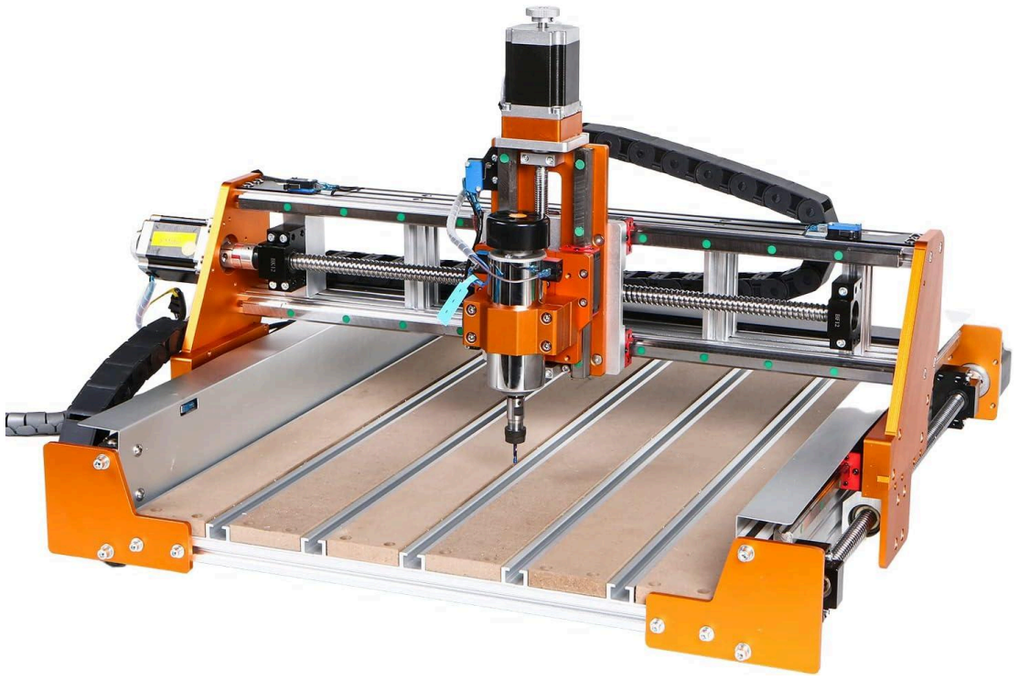
Mahogany will be used to make the main frame, or part 1 of the designs. While I initially planned to use red oak to create the prototype, mahogany was used instead because it is more widely available. Mahogany, which is a type of dark wood, has an attractive reddish-brown color, which will make the design aesthetically pleasing, especially when it is stained as I did with my first prototype (Mahogany Wood Advantages and Disadvantages). Since it is a hardwood, it has a very high density of 800 kg/m^3 (Mahogany). This is very advantageous as it makes mahogany very strong and durable. Mahogany is a hard wood and possesses very high tensile and stiffness, which is good as it means the design will be able to support the necessary weight of all the products without pulling apart or deforming. It is classified as having a durability of class 2, and can withstand outdoor conditions for 20 years without maintenance. Furthermore, mahogany is naturally water-resistant and rot-resistant due to its high density, which is beneficial as my design will be used in the shower where it will be exposed to lots of water (Mahogany Wood Advantages and Disadvantages).

All these benefits come with a slight tradeoff, however. Since mahogany is a hardwood, it also takes longer to grow, and as a result, is slightly less renewable and is costlier compared to softwoods. This is not that much of an issue as each product only uses a total of approximately 1.1 kg of wood, which is a pretty low amount. This is good because this small amount can be sustainably harvested from branches on live trees. Furthermore, both of these negatives are made up for. In terms of renewability and environmental impact, this is made up by the fact that the product can be used for several years without having to be replaced, meaning the net environmental impact over the entire product lifecycle is quite low (Mahogany Wood Advantages and Disadvantages). Furthermore, the cost is not an issue because I am creating a high-end product with high longevity, and is still within the appropriate price range as outlined in the specification.

Figure 30. Types of Mahogany

F2. Justify the Choice of Manufacturing Techniques Appropriate for Commercial Production

Computer Numerical Control (CNC) manufacturing will be used to manufacture the main frame or, part 1. This was originally what I planned to do for the prototype but could not since I did not have access to one. The advantage of CNC manufacturing is that it can cut part 1 out of a single piece of wood in a precise manner (10 Benefits of CNC Machining). This is necessary due to the amount of detailed curves and patterns which would take much longer to cut by hand.



Computer Aidded Design (CAD) Programs such as Fusion 360 and Shaper 3D can be used to allow customers to customize their products, such as engraving different designs or altering the shape of the product itself.

Shapr3D

AUTODESK®
FUSION 360™

Hand Sanding will be used to effectively smooth the design before applying stain and polyurethane. It was necessary to use hand sanding as it is difficult to use an electric sanding machine to sand the inside of the product. Furthermore, the sanding process will be done starting from low to high grit. The low grit is used to knock off any edges and uneven surfaces while the high grit is used to smooth the surface.

Finishing will be done once the design is fully built and sanded. The design will be finished with polyurethane which is applied to the design to protect it from water damage by sealing it.

F3. Justify an Appropriate Scale and Volume of Production, Based on Appropriate Research and Suitability for the Product

While the first designs were made specifically for my two clients, my research below has indicated that there is a large potential market throughout Egypt related to shower organization. This is due to the fact that designs can also be easily mass-produced, as well as mass-customized, using CNC manufacturing.

Phase 1:
In the first phase of production, the client base will be Maadi, which has a population of 95,000. Assuming that the top 5% have enough disposable income to afford the product, and that 15% of those actually want to buy the product, that gives an estimate of about 700 total units sold. Given the somewhat small volume, the products can be produced in batches, as the CNC machine can cut several of the same part at once, and many products can be assembled at the same time.

Phase 2:
In the second phase of production, the market will expand all of greater Cairo, which has a population of about 22 million people. Given that Cairo is slightly poorer than Maadi, I will assume that only the top 1% can afford it, and that 5% of those will actually buy it, that gives an estimate of about 12000 units sold. Given this higher number of products, continuous flow production will be implemented.

Phase 3:
In the final phase of production, the market will expand to all of Egypt, which has a population of 114 million. Assuming that the top 0.5% of the population will be able to afford the product, and that 5% of those will actually buy it, that gives an estimate of 29,000. At this phase of production, mass customization will be implemented as customers will be able to engrave their own designs onto the products. The base level products themselves will be manufactured continuously but then will be customized in batches or by hand.

Phase	Launch Market	Testing Period Before Next Phase	Production Scale	Production Volume	
				Low Estimate	High Estimate
0	2 clients	N/A	One-off	N/A	N/A
1	Maadi	2-4 weeks	Batch	400	1000
2	Cairo	1-2 months	Continuous Flow*	9000	15000
3	Egypt	3-6 months		20000	40000

*Mass customization will be implemented at this stage

Fixed Costs	Variable Costs (Per unit)
CNC Machine: $20,000	Materials: $10
	Labour: $4
	Shipping: $5
	Advertising/Promotion: $1
Total: $20,000	Total: $20

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Appendix

Client Interview Transcript:

Me: What do you think about the overal design of the product?

Client 1: It is very simplistic, which I like as it does not distract from the aesthetic of the shower.

Client 2: Yes I agree.

Me: What about the color scheme?

Client 1: I also like it because it is also simple. I don't like overly colorful designs so I like this simple design

Client 2: Yeah same, I like the simplicity of it.

Expert Appraisal:

“After thoroughly analyzing the design I can safely say that it is smooth enough and that I have not found any sharp corners.”

“After looking at the bill of materials and calculating the total cost, I found that cost of each of your products is about $14 or about 700 egp, which is below the 1000 egp maximum stated in your specification.”