https://bit.ly/4a39cLB

IGCSE Design and Technology

Project Name: Self Cleaning Toilet Seat

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Design Directions

I wanted to find the most appropriate concern for me to consider. To do this, I looked at a variety of problems people face. I looked online, spoke to people and observed my friends and family, to shortlist a few that I thought would allow me to find a good solution while also learning the process.

1. People find it hard to reach the top shelves of supermarkets - https://bit.ly/3TtDOAb

2. Restaurant drive are becoming more popular, however plates given are not always the best for carrying and storage of edibles - https://bit.ly/3uVs1kZ

3. Carrying additional luggage in the back seat from rocking and getting flung around the car - https://bit.ly/48NRqe3

4. Mainly restaurants use sleeves to hold cutlery. The problem with this is that it can be difficult for the restaurant to place other items, such as napkins or wet wipes, in the sleeves - https://bit.ly/3IxWnNE.

5. In public bathrooms, a lot of the time people have problems with the cleanliness of toilet seats. - https://bit.ly/3Tw0JuE

Justification & evidences

Public toilets can be a concern in multiple ways. While mostly it has a requirement for a change in behavior, sometimes it is also possible that people forget to lift the seat post use or flush. This unhygienic practice can lead to people not being able to use the washrooms. These washrooms can also be a health hazard for multiple people, and can be extremely dangerous.

We do have a few washrooms which are cleaned regularly and users need to pay. However, this is limited. And everyone needs to use them at some point or the other, be it in school, outside or during travelling.

For the same, I feel this problem should be taken forward as it not only is a good opportunity area in a local setup, but also something that can be scalable.


ROSS CLINICS

Hazards associated with public restrooms

Amongst the human population a large number of diseases that are infective spread through contact and as human beings travel frequently more and more and transit through spaces like airports, malls and markets - one place which can be a hub for spreading infection is the public restroom.

Certain viruses spread from one person to the other from surfaces of common use - like doorknobs, washroom counters and taps.

There are bacteria that spread from one human host to the other through what is known as the Oro-fecal route. If there is touching of the toilet seat with feces and body fluids etc then one who uses the toilet might get contaminated, and if then one is not careful of hand hygiene it may lead to infection, infection and subsequently disease. Examples of such diseases are - Typhoid fever, Hepatitis or liver


ROSS CLINICS

infection and worm infestation

Urinary infection: Very often the source of urinary tract infection is from contact with a dirty toilet seat

Skin and fungal infection - the spores of fungus that infect human skin thrive in the moist and warm environs of public restrooms and in person who may be susceptible there is a high chance of getting an infection.

Dr. Sveta Bhardwaj (Occupation: General Practitioners)

By interviewing doctors, family, friends, and the general users, I came to the conclusion that most people believe that issue 5 is highly relevant in today's day and age, and a solution for this is very important

Research

To conduct the research efficiently, I divided my research into 2 categories: the ways to clean the seat, and the technology that can be used to clean the seat. I referred to the products selling in online markets and actual markets to gather sufficient information for the development of my product. I also conducted a research related to ergonomics and posture in order to have better understanding of my design problem.

Ways to clean the seat

Toilet Seat Sanitisers -
https://bit.ly/49EWWkA
Aesthetic - Cylindrical shape allows an easy hold
Cost - ₹95 - ₹110 (€1.05 - €1.22)
Customer - Travelers and users of public toilets
Environment - Recyclable components along with some non degradable parts
Safety - Can be harmful if sprayed in eyes
Size - 50ml - 100ml
Function - Compressed gas, released when nozzle pressed
Material - Plastic, Metal, Paints
Manufacture - Cap = Vacuum Forming; Body = Cold Rolled ; Nozzle = Injection Molding
Constraints - Gas can finish abruptly. Spray kills germs not cleans surface
Social - Mechanized production. Won't be produced locally

Disposable toilet seat covers -
https://bit.ly/3To1E0k
Aesthetic - Highly functional but not aesthetic
Cost - ₹7 - ₹16 (€0.078 - €0.18)
Customer - Public toilet users and at times for personal use
Environment - Biodegradable
Safety - Comfortable to sit on. In wet conditions may stick
Size - 40.6cm - 43.2cm
Function - Put on seat like a sleeve or covering
Material - Paper
Manufacture - Paper Mills
Constraints - Resource is non replenishable
Social - Waste is degradable but recycling may not be done locally

Cleaning the seat with toilet paper -
https://bit.ly/4c4kwsE
Aesthetic - Soft and comfortable
Cost - ₹30 - ₹100 (€0.33 - €1.11)
Customer - Public toilet users and at times for personal use
Environment - Biodegradable
Safety - Comfortable to sit on. In wet conditions may stick. May tear
Size - 40.6cm - 43.2cm
Function - For wiping seats and to sit on
Material - Paper
Manufacture - Paper Mills
Constraints - Resource is non replenishable
Social - Waste is degradable but recycling is not possible

Alcohol wipes -
https://bit.ly/4a1EP84
Aesthetic - Feels good because of the smell
Cost - ₹2 - ₹6 (€0.022 - €0.067)
Customer - People who use public and/or dirty toilets
Environment - Can be biodegradable and non biodegradable, depending on the material
Safety - May hurt when touched with cuts, or skin may react
Size - 18cm² - 255cm²
Function - For wiping seats
Material - Plastic-based materials or biodegradable non-woven fabrics
Manufacture - Weaving loom
Constraints - Only one use per wipe
Social - Can be locally sourced

UV Lights - https://bit.ly/3P4z9Cs
Aesthetic - The blue ultraviolet light may intrigue some users
Cost - ₹799 - ₹20,589 (€8.87 - €228.62)
Customer - Users of public toilets and bathrooms
Environment - One product works for every user.
Safety - May stun people due to the unusual blue light
Size - 40.6cm - 43.2cm
Function - For cleaning the toilet seat and bowl using ultraviolet light
Material - UV Light Emitting Diodes
Manufacture - Semiconductor wafer
Constraints - If multiple public toilets are present, price can build up
Social - Building may not be done locally, but installation can be

Research

Manual Cleaners -
https://bit.ly/4326EuN
Aesthetic - Blue color signifies hygiene
Cost - ₹90 - ₹100 (€1 - €1.11)
Customer - Inexpensive makes it feasible for all
Environment - Acid in nature. Land and Water Pollution
Safety - Chemical composition, so should not be ingested
Size - 500ml
Function - Place it part inverted and press for liquid to release.
Material - HDPE Plastic Contents = Hydrochloric Acid, Cetyl Trimethyl Ammonium Chloride
Manufacture - Blow Molding and Injection Molding
Constraints - Not reusable or refillable
Social - Users cleaning washrooms require protective gear

Squatting pan -
https://bit.ly/3wOiCMo
Aesthetic - Hides certain parts of the toilet
Cost - ₹2599 - ₹3499 (€28.82 - €38.80)
Customer - Public toilet users
Environment - Non degradable
Safety - The user might fall in the toilet.
Size - 51cm radius
Function - To hide certain parts of the toilet from the user.
Material - White China (Ceramic) and Stainless Steel
Manufacture - Molding Process
Constraints - Non repairable - may not get fully cleaned
Social - Require industrial production.

Multifunctional/Smart toilets -
https://bit.ly/3uX6GHO
Aesthetic - Looks futuristics
Cost - ₹96270 - ₹112300 (€1067.59 - €1245.35)
Customer - Niche customers
Environment - Built-in automatic energy saving
Safety - Sensors might not function properly
Size - 67.8cm x 40.9cm x 50.8 cm
Function - To automatically flush, lift and heat the toilet seat.
Material - Ceramic, Acrylonitrile Butadiene Styrene
Manufacture - Molding Process
Constraints - Expensive, and only for certain people
Social - Not made in-house

Automatic plastic seat covers -
https://bit.ly/437meoP
Aesthetic - Highly functional but not aesthetic
Cost - ₹4999- ₹7999 (€55.44 - €188.71)
Customer - People who use public and/or dirty toilets
Environment - Is biodegradable
Safety - Skin may react
Size - 40.6cm - 43.2cm
Function - To replace the plastic seat cover after every user
Material - Oxo-biodegradable plastic
Manufacture - By blending a pro-degradent additive into the plastic
Constraints - Some might find the seat uncomfortable, due to the materials
Social - Cannot be made on site

Technology that can be used

Proximity sensors -
https://bit.ly/4c0dwwR
Cost - ₹230 (€2.55)
Customer - Public toilets users
Size - 0.4cm x 2cm
Function - To detect how close an object is to the sensor and bowl using ultraviolet light
Material - Stainless Steel

Thermal sensors -
https://bit.ly/3uNbyiM
Cost - ₹100 (€1.11)
Customer - People who use public and/or dirty toilets
Size - 16cm x 16cm
Function – To detect the temperature of the object
Material - Nickel, platinum, and copper

Foot lever - https://bit.ly/4c3RWHD
Cost - ₹1353 (€15)
Customer - User's of public toilets and bathrooms
Size - 40cm² (8cm x 5cm) - 50cm² (10cm x 5cm)
Function - To use your foot to push or pull-on levers
Material - Electroplated Mild Steel

Motion detection sensors -
https://bit.ly/3T4KN19
Cost - ₹62 (€0.69)
Customer - Public toilets users
Size - 3.2cm x 2.4cm x 1.8cm
Function - To detect motion
Material - Pyroelectric sensor and conditioning circuitry

Servo Motor -
https://bit.ly/3Tm3pew
Cost - ₹898 (€9.95)
Customer - User's of public toilets and bathrooms
Size - 40mm x 20mm x 43mm
Function - To turn objects using its motor
Material - Body = plastic; Inside = Conditioning circuitry

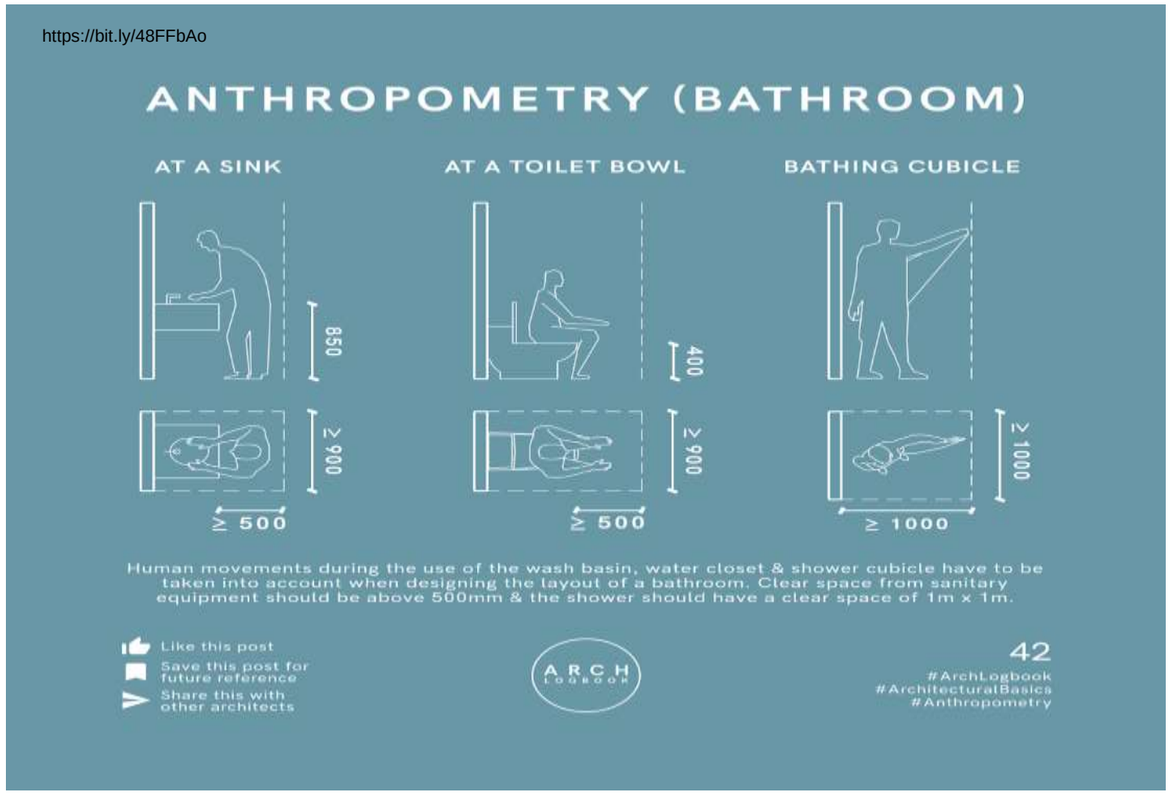
As I have come across many different products while doing my market and internet research, I saw that most of the product designs helped to reduce the number of dirty washrooms and prevent the spread of diseases, while some did not. When I investigated those products, which failed to meet the needs of people, I realized that it apparently did manage to serve its purpose, however only for a small number of people. This made me recognize the importance of investigating cleaning methods which could be found comfortable by the majority of people.

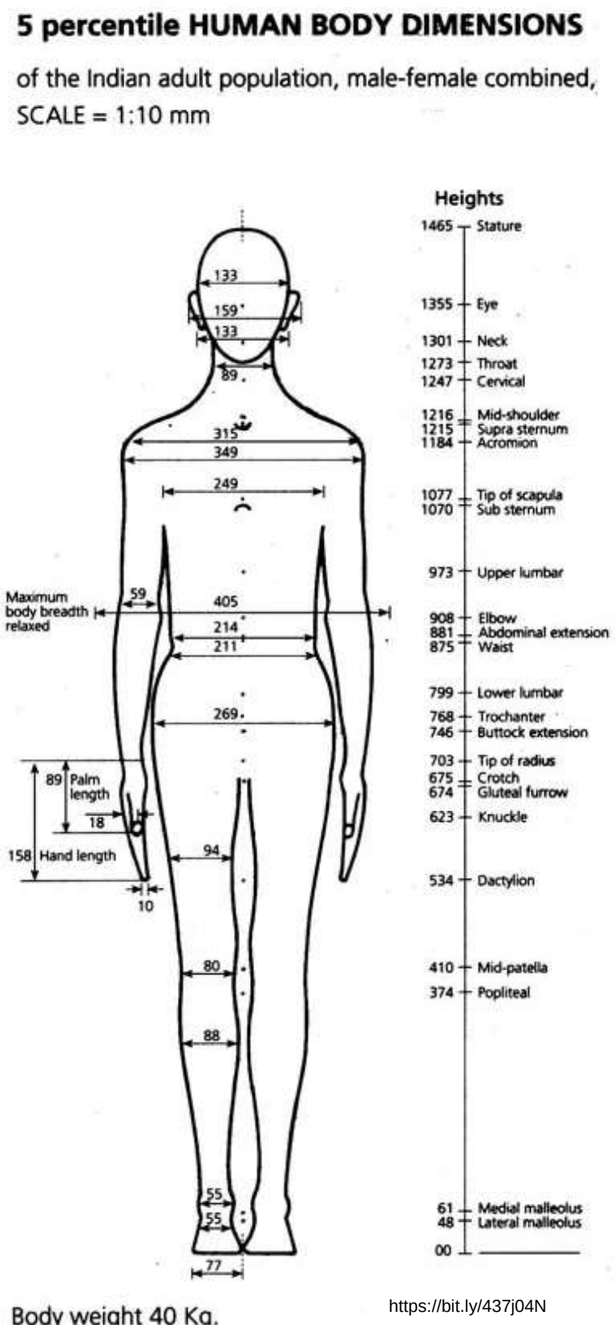
Anthropometric Data

Piezo pressure sensors -
https://bit.ly/3V4Vh36
Cost - ₹69 (€0.76)
Customer - Travelers and users of public toilets
Size - 4.4cm x 3.81cm
Function - To detect pressure
Material - Quarts

Distance sensor -
https://bit.ly/4376FgR
Cost - ₹79 (€0.87)
Customer - People who use public and/or dirty toilets
Size - 4.5cm x 2cm
Function - To detect the distance using ultrasound
Material - Non-substrate materials with layers of copper circuitry

https://bit.ly/48FFbAo





https://bit.ly/437j04N

I used this research to determine how wide my toilet seat should be, by looking at the Human Body Dimensions. After doing this I checked the average size of the bathroom stall to ensure that people will be able to sit comfortably.

Specifications & Design Brief

Identifying the advantages and disadvantages of various products has helped me to deduce certain functions that are necessary for a self-cleaning toilet seat. I thus listed down those aspects which would help me to develop my ideas according to the need and convenience of users. Post observing and understanding the chosen design problem, I also perceived how users find a solution for the problem through my research which has helped me to develop the design brief.

Specifications

Lightweight
To allow the user to use the product in different places whenever in need, the product should be portable. Reducing the weight of the product will make it convenient for user to carry the product along.

Moisture Resistant
The product should be able to resist the penetration of water to some degree but not entirely.

Simplified Tasks
The product should be simple and easy to use.

Low Maintenance
The product should require little work to keep in good condition.

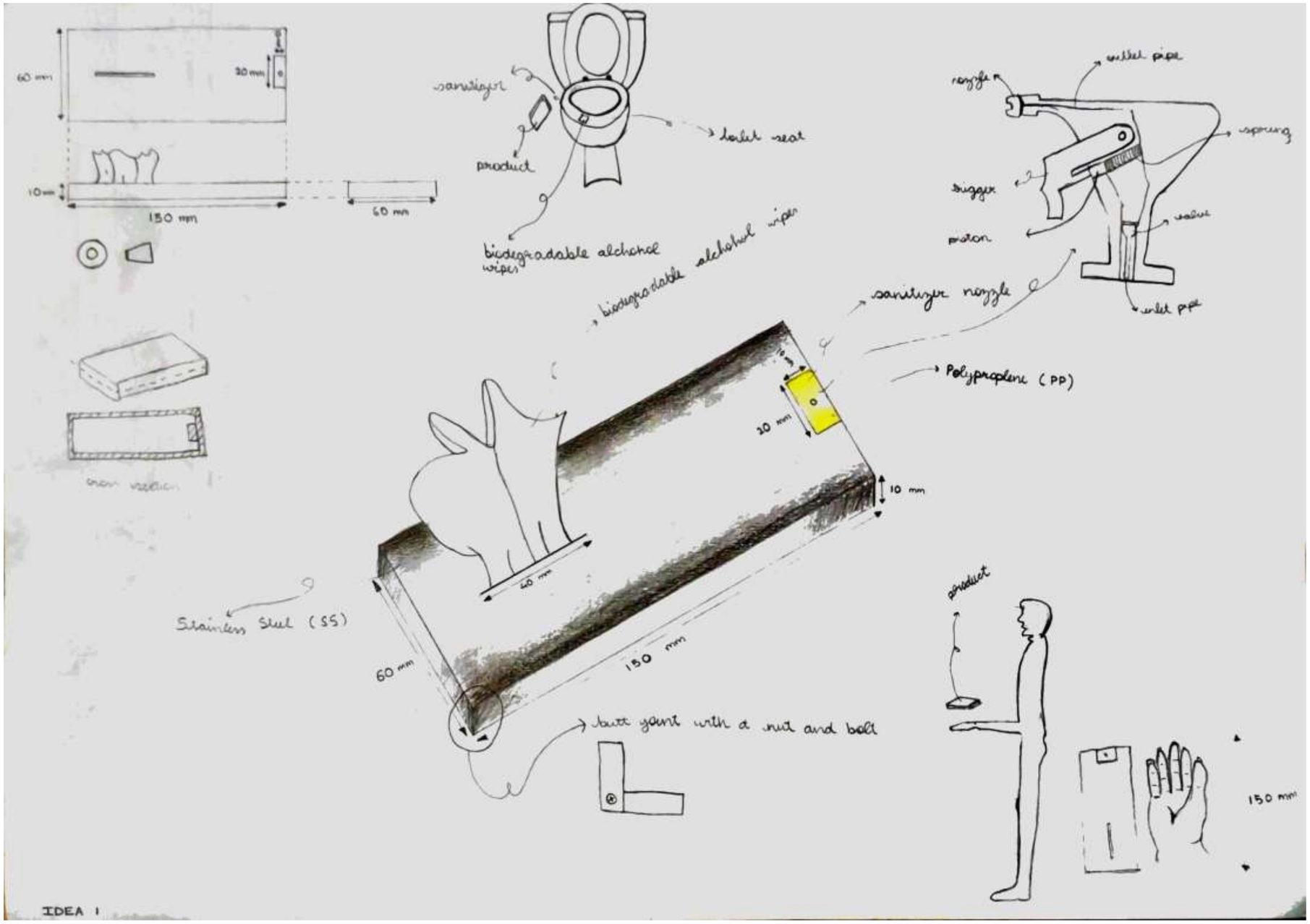
Low Human Intervention Needed
The product should keep the human involvement or involvement of other resources to a minimum

Design Brief

In public bathrooms, a lot of the time people have problems with the cleanliness of toilet seats, because it is dirty from before, due to other users. Cleaning can also be an issue due to the fact that there's a lot of cleaning equipment required, and sometimes, due to storage issues, finding this cleaning equipment is difficult. Also installing high-tech components may be expensive and is likely to be stolen. For this, I would like to create a solution that is easy to maintain, and at times allows for low human intervention. This product should simplify tasks to increase cleanliness as an approach and a mindset. I would like the product to also be lightweight, so that it is not cumbersome to install. As the product will be used in a washroom, it should be moisture resistant.

Idea Generation

Idea 1



Description

This is a small pocket sized box (of dimensions 150mm*60mm*10mm – l*b*h), which contain both a sanitizer that the user can spray on the toilet seat, as well as wipes so that you can remove grime and dirt off the toilet seat.

This idea contains a spray, which the sanitizer comes out of, as well as a slit where the user can pull the tissues out off

The box itself is made out of stainless steel, whereas the nozzle for the sanitizer is made out of Polypropylene (PP)

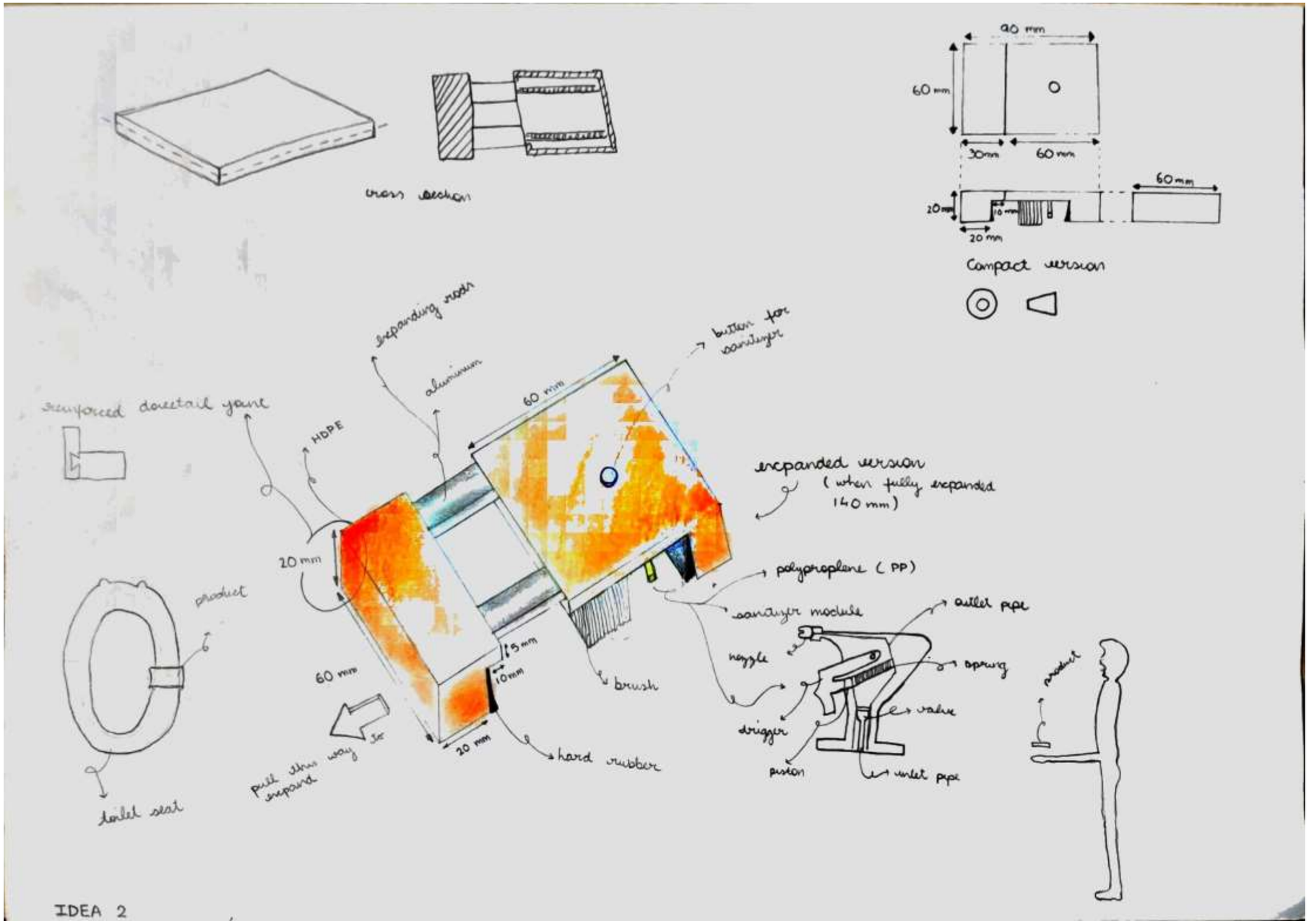
The possible ways to develop this product are using laser-cutting and bending, as well as thermoforming

Some users may prefer this product due to the fact that it is lightweight, moisture resistant, and simplifies the tasks. On the other hand, some users may not like this product as human intervention is required in public areas, which can be a hygiene issue, and it is not low maintenance.

Lightweight	Moisture Resistant	Simplified Tasks	Low Maintenance	Low Human Intervention Needed

Idea Generation

Idea 2



Description

This is a portable attachment (of dimensions 90mm*60mm*20mm), which extends, so that the user can spray sanitizer on the toilet seat, as well as use the brush to wipe the grime and dirt off the toilet seat.

This idea contains a spray, which the sanitizer comes out of, as well as a brush, which pushes the dirt off the seat. This product also has the ability to collapse, as it extends to go around the toilet seat

The box itself is made out of HDPE (High Density Polyethene), whereas the nozzle for the sanitizer is made out of Polypropylene (PP), and the expanding rods are made out of Aluminum

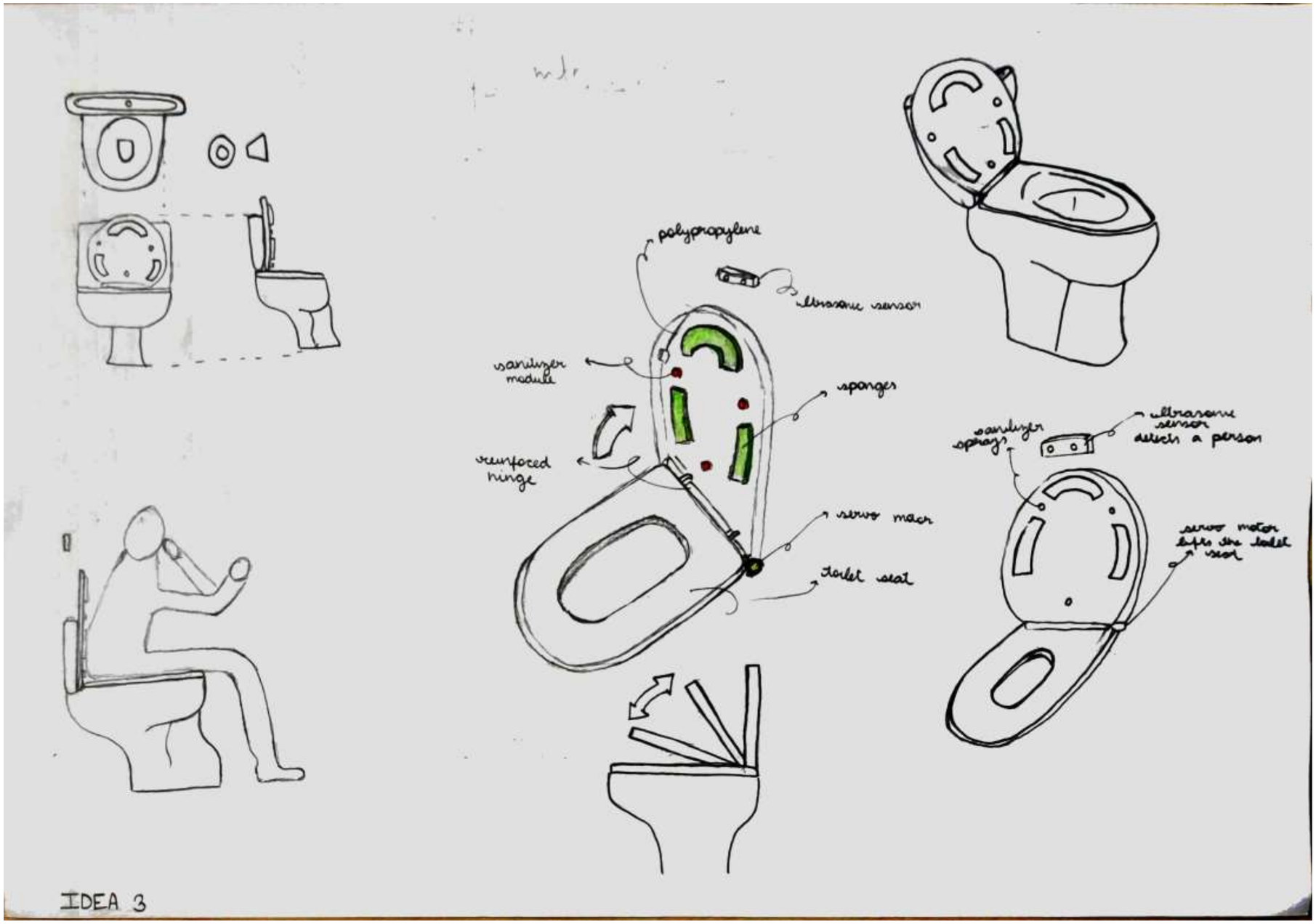
The possible ways to develop this product are using laser-cutting and bending, as well as thermoforming

Some users may prefer this product due to the fact that it is lightweight, moisture resistant, and low maintenance. On the other hand, some users may not like this product as human intervention is required in public areas, which can be a hygiene issue, and it may not simplify tasks.

Lightweight	Moisture Resistant	Simplified Tasks	Low Maintenance	Low Human Intervention Needed

Idea Generation

Idea 3



Lightweight	Moisture Resistant	Simplified Tasks	Low Maintenance	Low Human Intervention Needed

Description

This is a replacement for the current toilet seat, which automatically covers the toilet seat after a use, so that sanitizer can be sprayed on the toilet seat, as well as use the sponges to absorb the liquids off the toilet seat.

This idea contains a spray, which the sanitizer comes out of, as well as sponges, which absorb the liquids off the seat. This product also uses ultrasonic sensors with an Arduino and Servo motors, to detect the presence of a user, and move the seat cover down

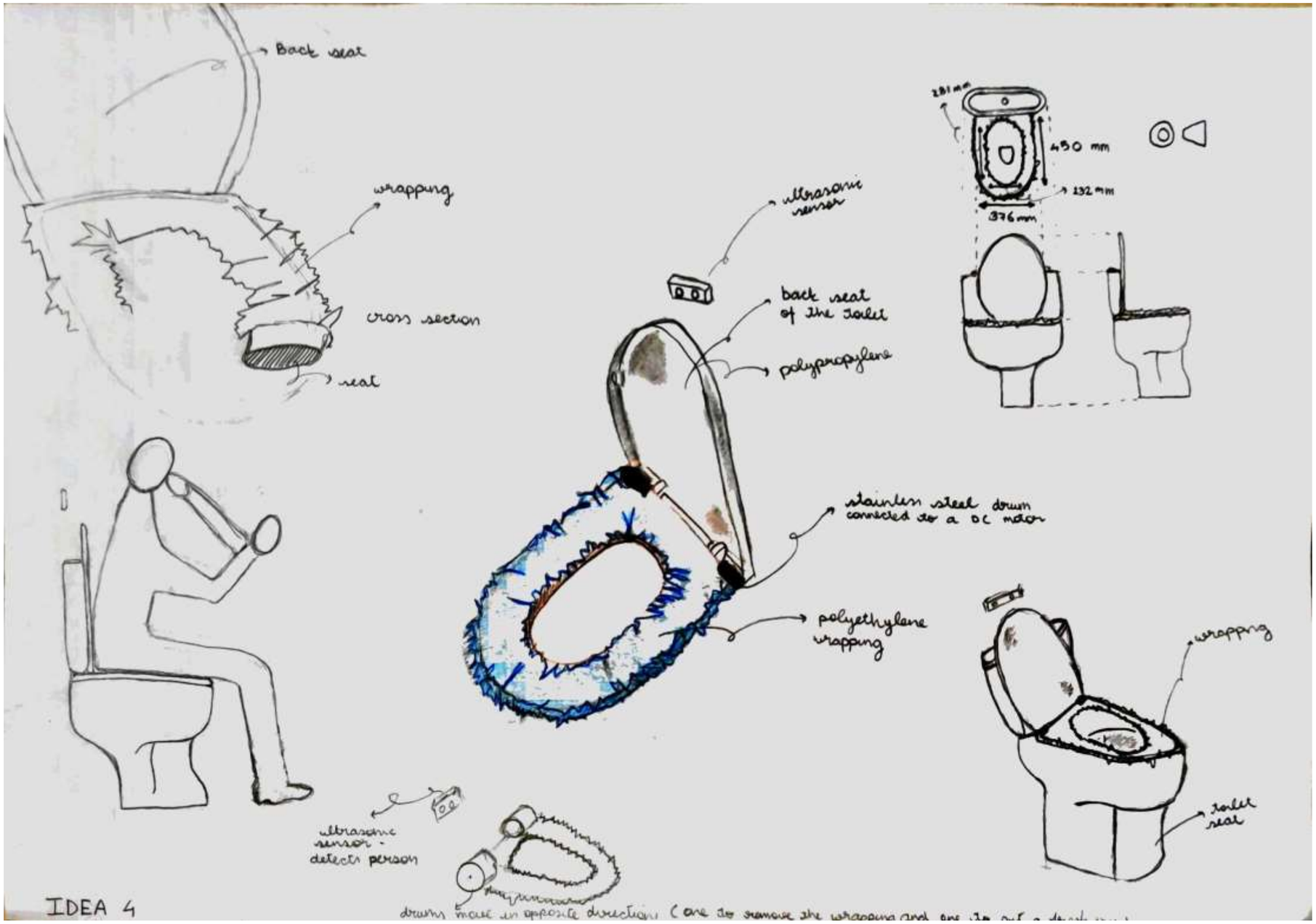
The cover and seat itself is made out of Polypropylene (PP), where as hinge for the seat has been reinforced with Stainless Steel (SS)

The possible ways to develop this product are using thermoforming and injection molding, as well as laser-cutting and bending

Some users may prefer this product due to the fact that it simplifies tasks, is low maintenance, and requires low human intervention. On the other hand, some users may not like this product as it is not lightweight, and will be required to be installed in public areas, and is not moisture resistant.

Idea Generation

Idea 4



Description

This is a replacement for the current toilet seat, which automatically detects whether a new user has entered the stall, so that the polyethene wrapping an be replaced.

This idea contains a roll of biodegradable polyethene wrapping, which covers the seat for user, preventing grim, dirt and germs. This product also uses ultrasonic sensors with an Arduino and Servo motors, to detect the presence of a user, and replace the wrapping on the toilet seat

The cover and seat itself is made out of Polypropylene (PP), where as hinge for the seat has been reinforced with Stainless Steel (SS), and the wrapping that goes on the seat is made out of biodegradable polyethylene.

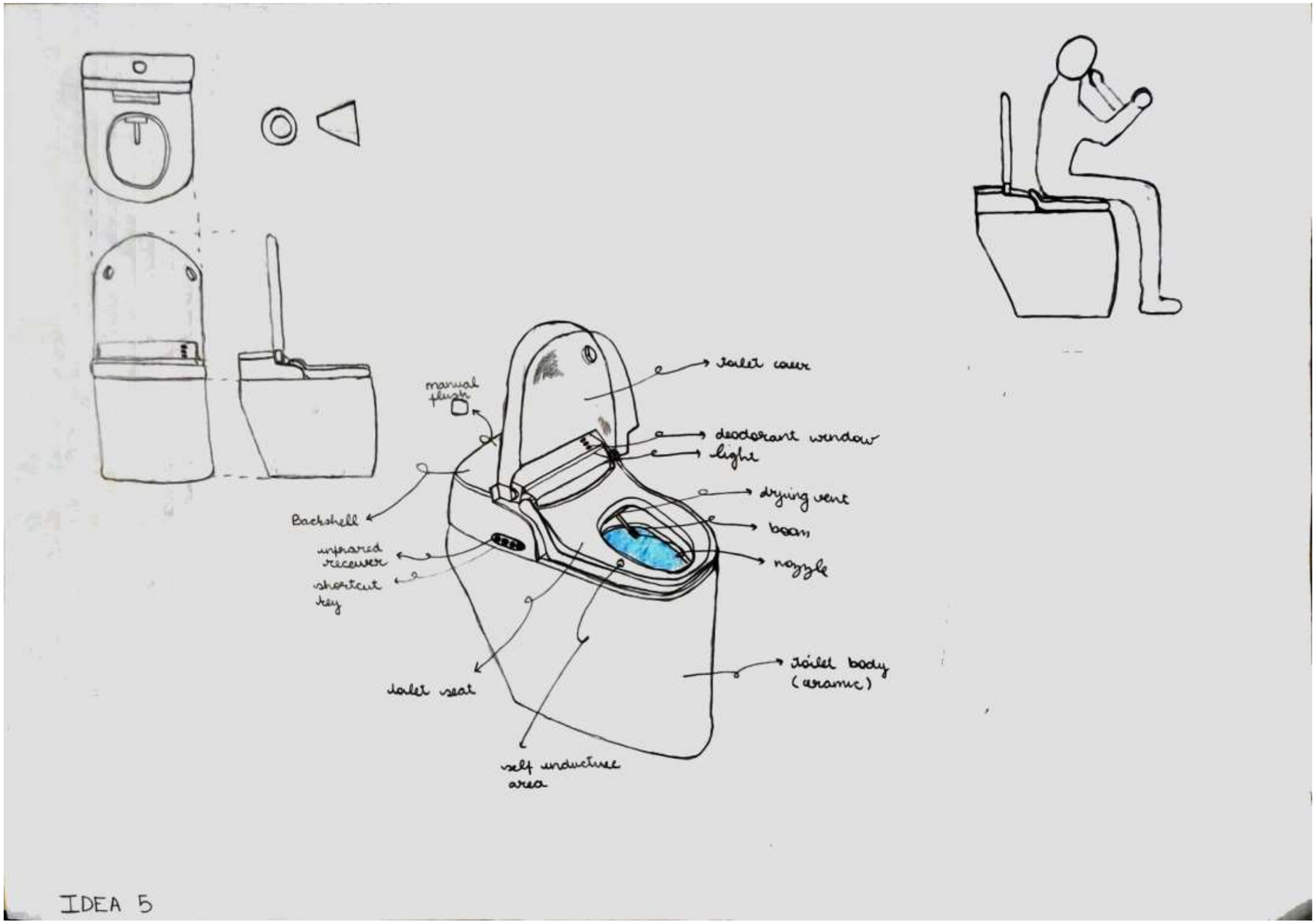
The possible ways to develop this product are using thermoforming and injection molding, as well as laser-cutting and bending

Some users may prefer this product due to the fact that it simplifies tasks, is low maintenance, and requires low human intervention, and is moisture resistant. On the other hand, some users may not like this product as it is not lightweight and will be required to be installed in public areas.

Lightweight	Moisture Resistant	Simplified Tasks	Low Maintenance	Low Human Intervention Needed

Idea Generation

Idea 5



Description

This is a replacement for the current toilet, which acts similarly to a smart toilet. It contains UV lighting for sterilization, as well as vents and nozzles to dry the toilet seat after a use.

This idea ‘smart’ toilet, which uses methods such as UV lights, nozzles, as well as vents to dry the seat and bowl and keep the toilet free of dirt.

The cover and seat itself is made out of Polypropylene (PP), where as the toilet body has been made out of ceramic.

The possible ways to develop this product are using thermoforming and injection molding, as well as glass blowing

Some users may prefer this product due to the fact that it is moisture resistant, and requires low human intervention. On the other hand, some users may not like this product as it is not lightweight, and will be required to be installed in public areas. They may also not like this product as it requires a high level of maintenance, and does not simplify tasks.

Lightweight	Moisture Resistant	Simplified Tasks	Low Maintenance	Low Human Intervention Needed

Idea Evaluation

IDEA 1	1	Sustainable development at its peak
IDEA 2	II	sustainable + automatic – convenient
IDEA 3	1	doesnot require human interaction
IDEA 4	IIII 1	SIMPLE ; EFFICIENT ! Master for minimal human involvement. Good idea!! very convenient. makes toilet clean - I find this idea to be the most practical since it doesn't require any work to be done by the user - most practical - completely hands free & the idea that a fresh sheet will be there for each person sounds very hygenic
IDEA 5	1	doesn't like a very happy idea

Idea evaluation

To decide which idea to take forward I did 2 things;

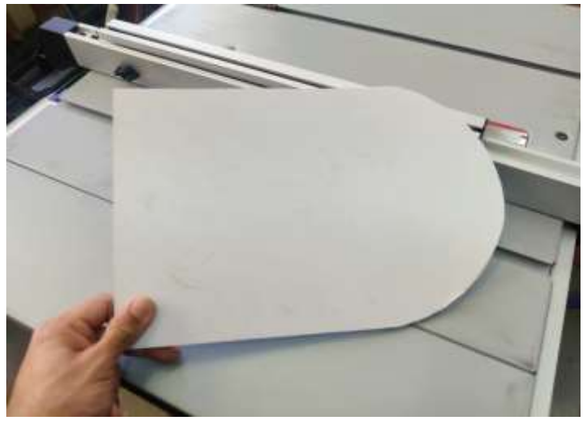
1. I compared each idea to my specifications as can be seen below each idea. This would help me get an understanding of what may work and what may not. This also gave me an idea of how to club different features together.

2. I did a user survey, to find the most appropriate solution. This would help me understand user perspectives, and things I could use to build my idea better.

I released that both idea 2 and 4 seemed good choices. Hence, taking into account the opinions of users and assessment on the specifications, I decided to take idea 4 forward.

	Lightweight	Moisture Resistant	Simplified Tasks	Low Maintenance	Low Human Intervention Needed
Idea 1					
Idea 2					
Idea 3					
Idea 4					
Idea 5					

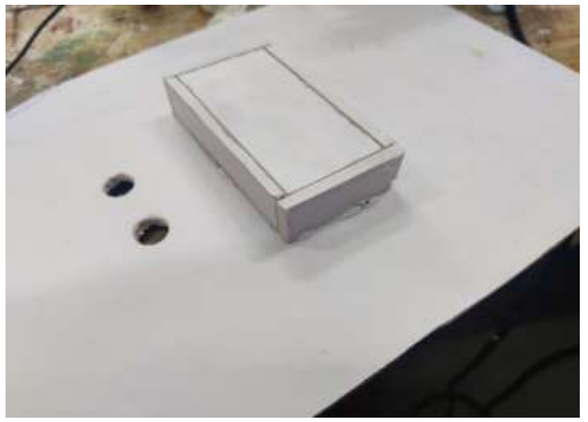
Detailing of proposed idea: Mockup



First I used foam-board to cut out 2 elongated semi-circles, of the same size. These 2 would serve as both the toilet seat cover as well as the toilet seat.

Out of 1 of these elongated semi-circles, I drilled two holes of the same radius to be a place where the ultrasonic sensor could be placed

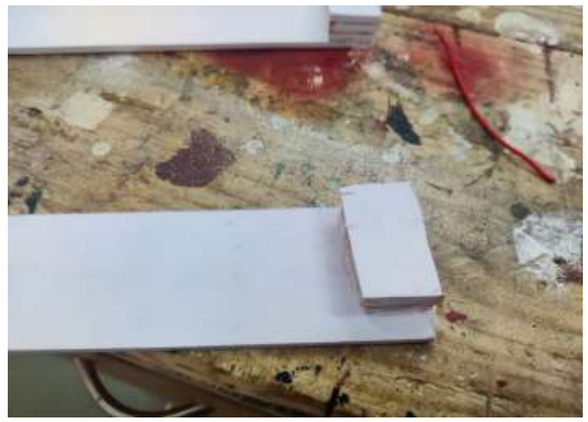
After this, I cut 6 pieces of foam-board to make a box shaped container that would hold all of the electronics. I glued all of these separate pieces together using hot glue



I then took this newly made container and stuck it to the back of my toilet seat cover using hot glue. This would then protect all the electrical components from damage.

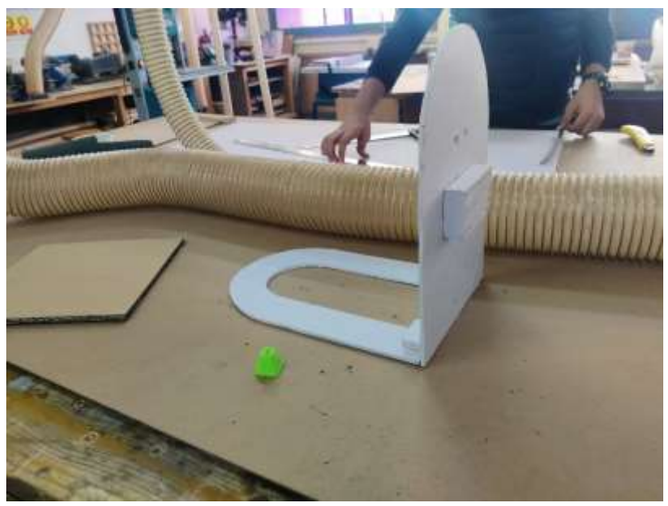
Using the second piece of the elongated semi-circles, I cut out the centre to act like my toilet seat.

I then stacked pieces of foam-board and hot glued them together to act as DC motors.



I then duplicated the last step and stuck both of the cubes on each side of the toilet seat.

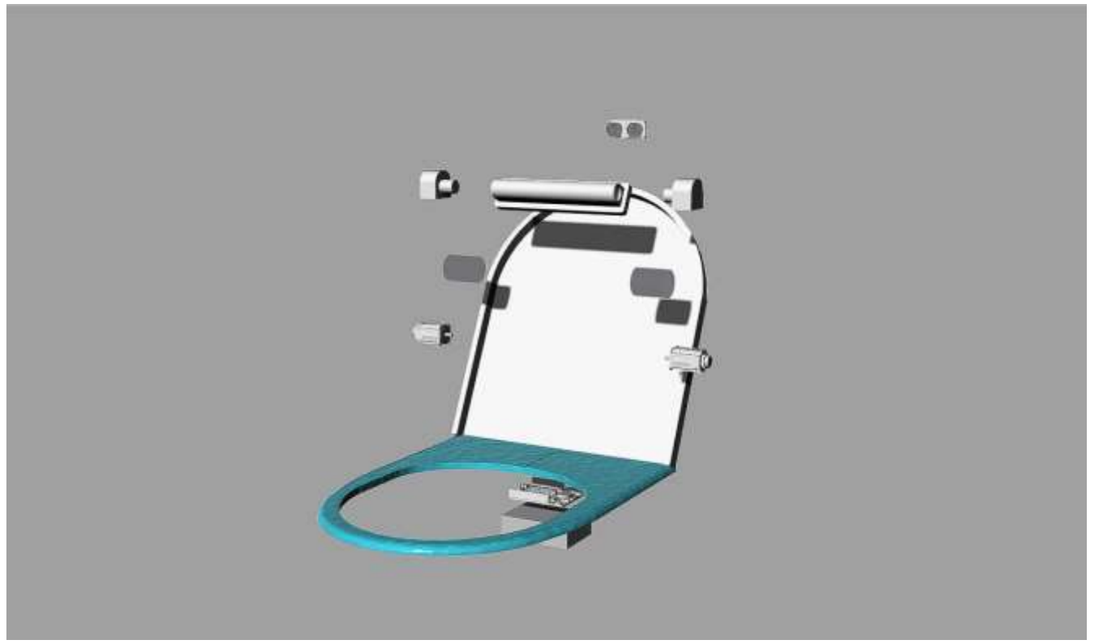
Lastly, I used hot glue to stick the toilet seat cover on to the seat.



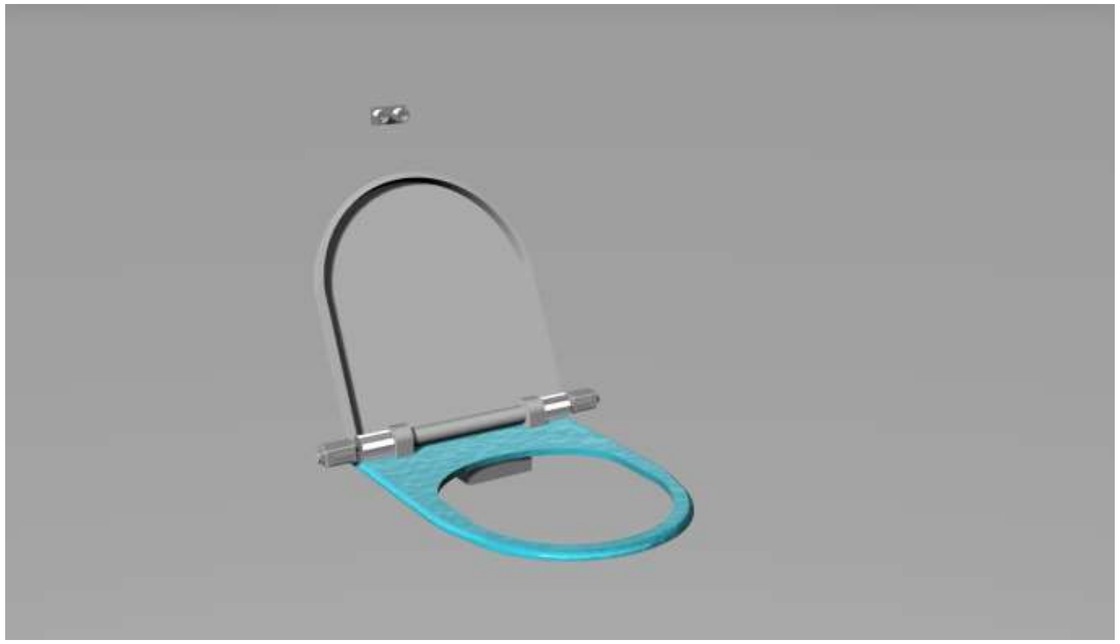
Detailing of proposed idea: CAD Drawings

After I had evaluated my mockup, I moved on to the detailed development of my product by using CAD. I looked into the actual dimension and working mechanisms of my product and made necessary changes, including the implementation of new mechanisms.

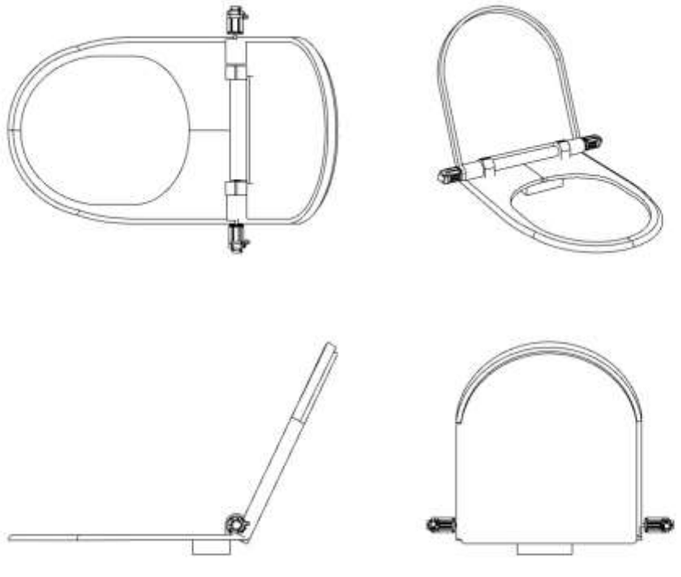
Exploded View



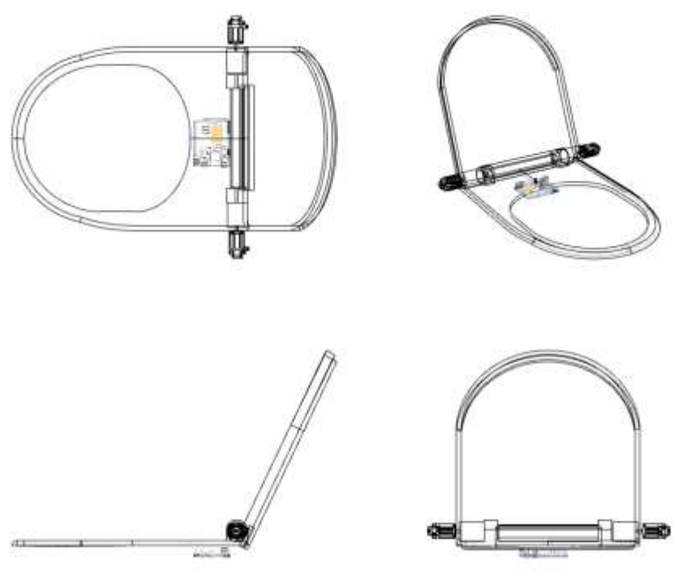
Assembled View

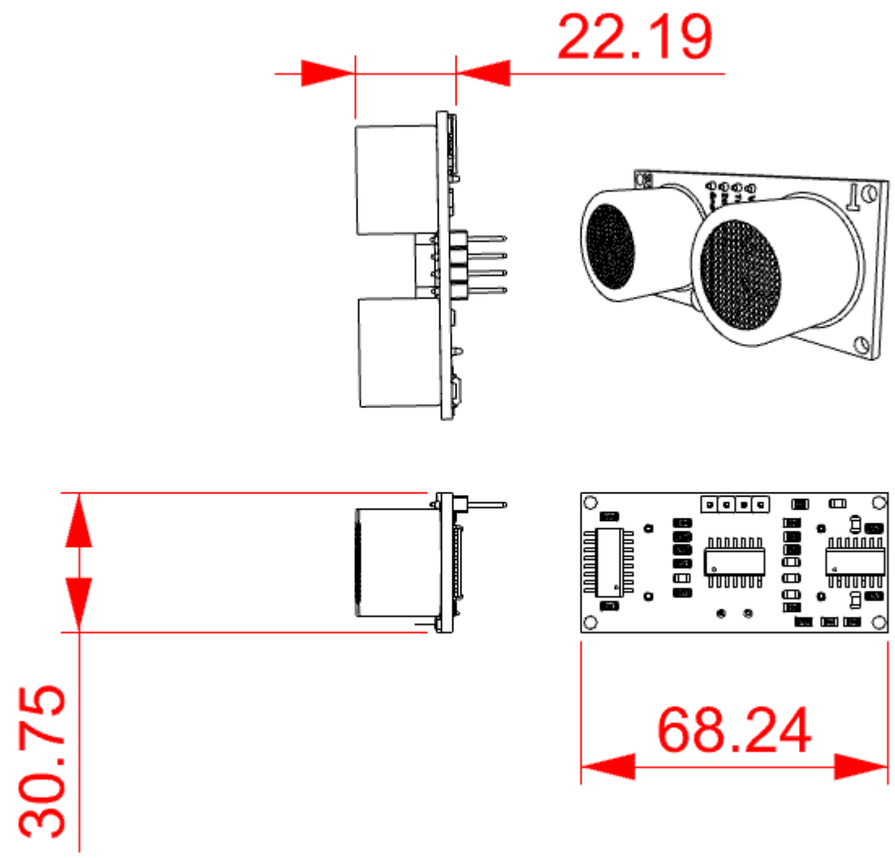


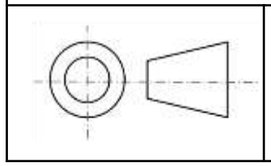
Assembled View (With-out hidden details)

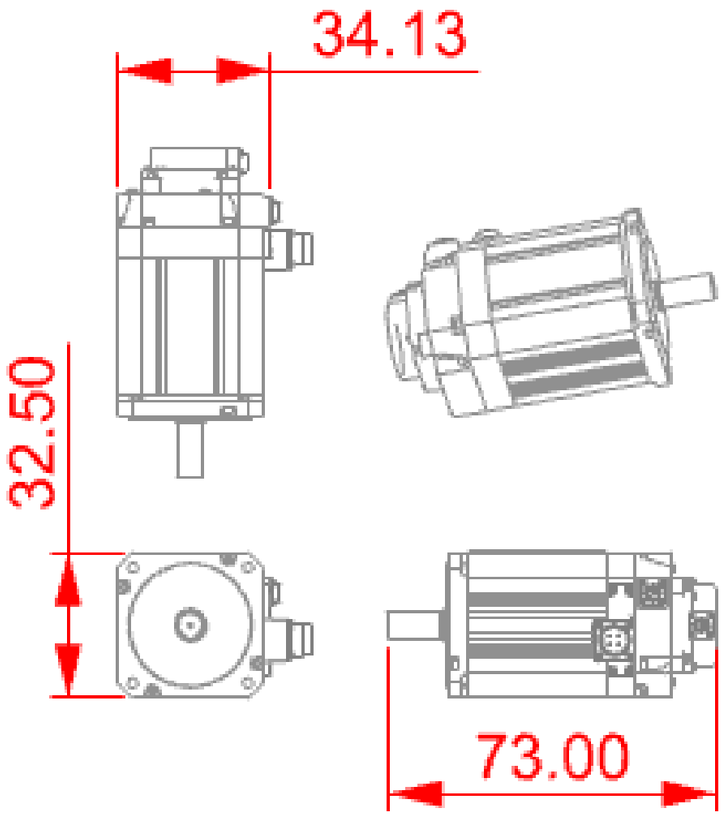


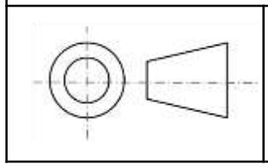
Assembled View (With hidden details)

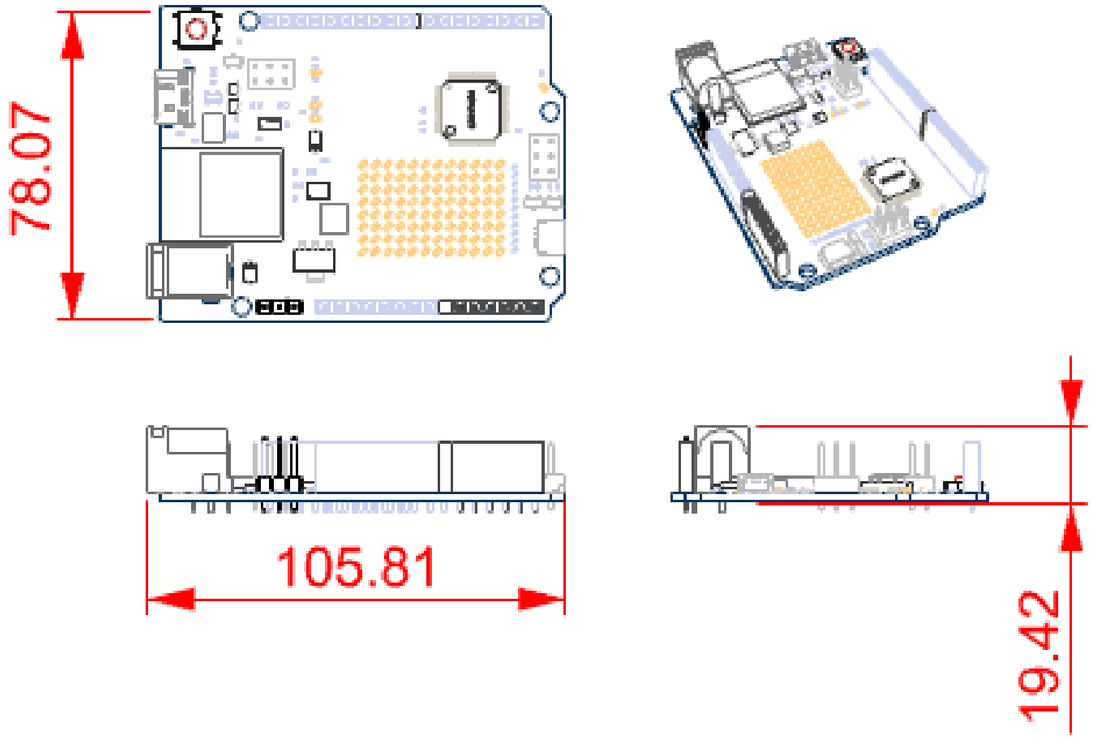


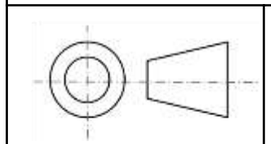


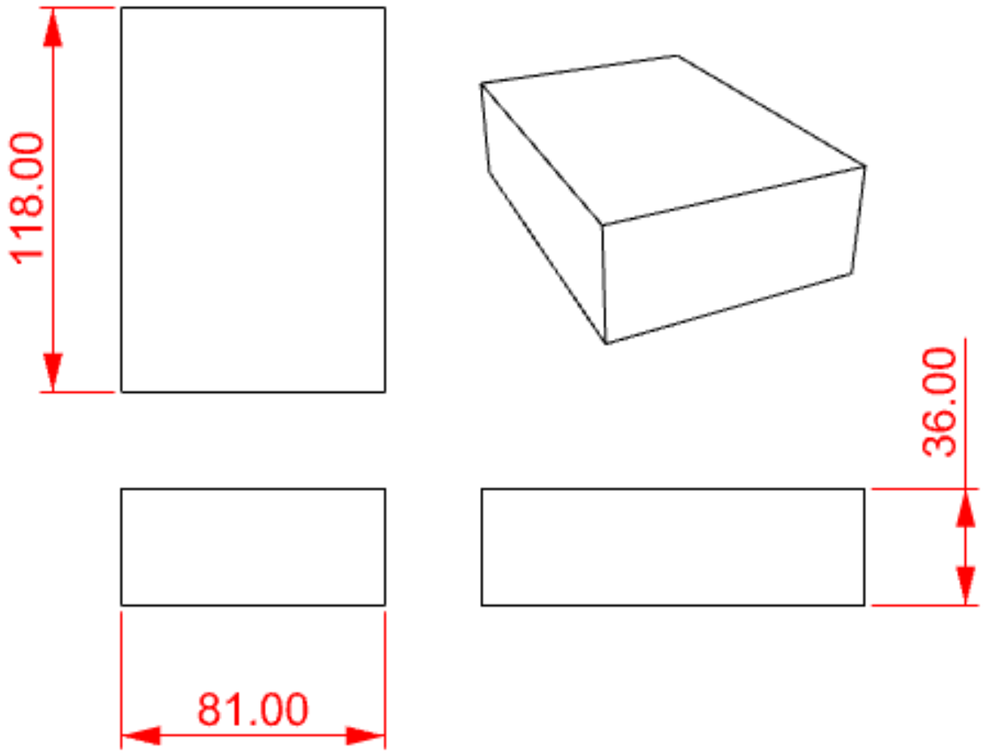
Ultrasonic Sensor			
	All Dimensions in mm	Scale 1:1	Piezoelectric material
		Full Drawing	March 2024

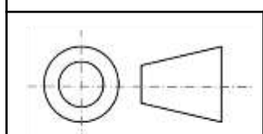


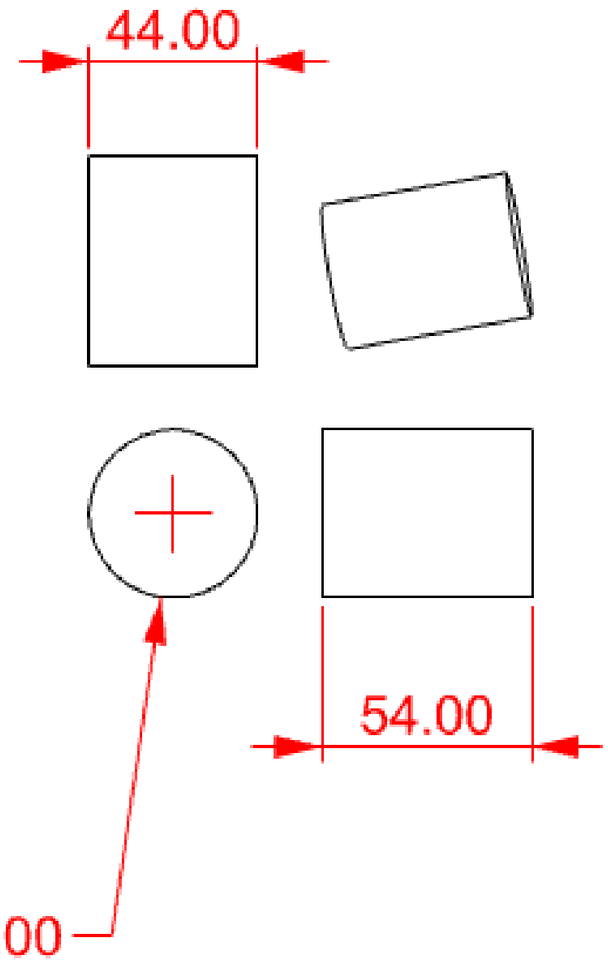
DC Motor			
	All Dimensions in mm	Scale 1:1	Copper, Iron and Aluminium
		Full Drawing	March 2024

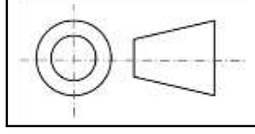


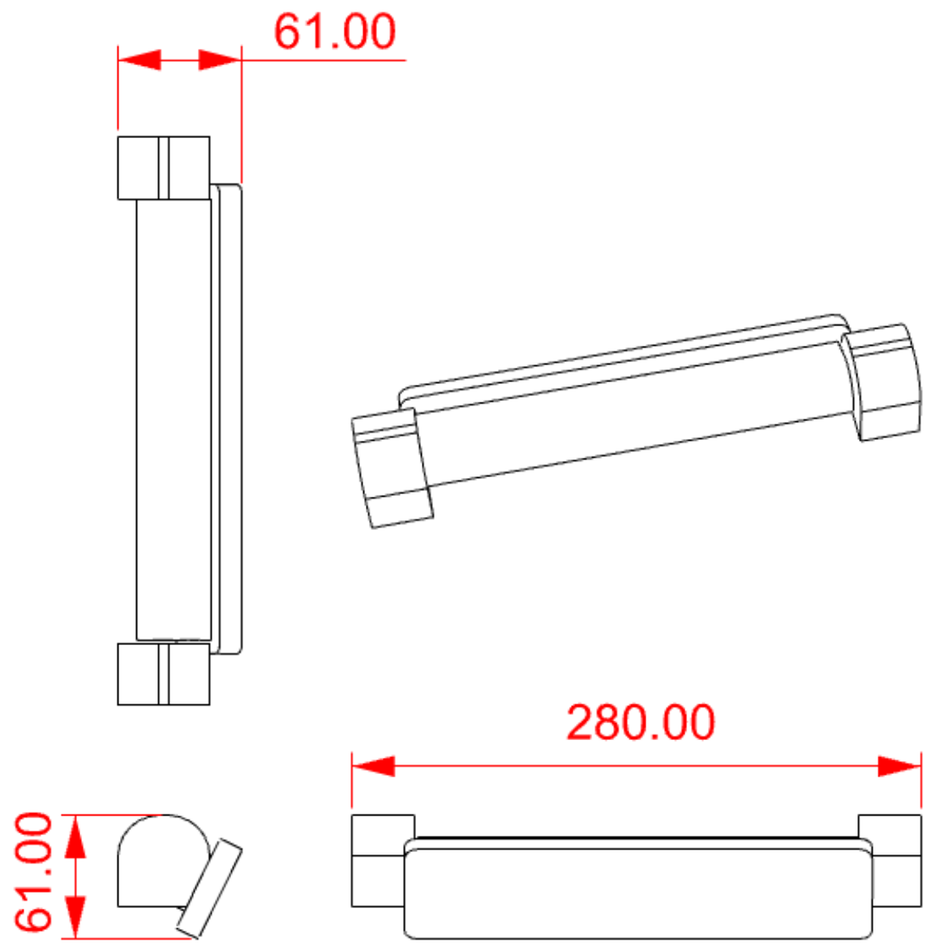
Arduino Uno			
	All Dimensions in mm	Scale 1:1	Atmel 8-bit AVR microcontroller
		Full Drawing	March 2024

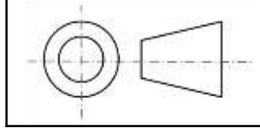


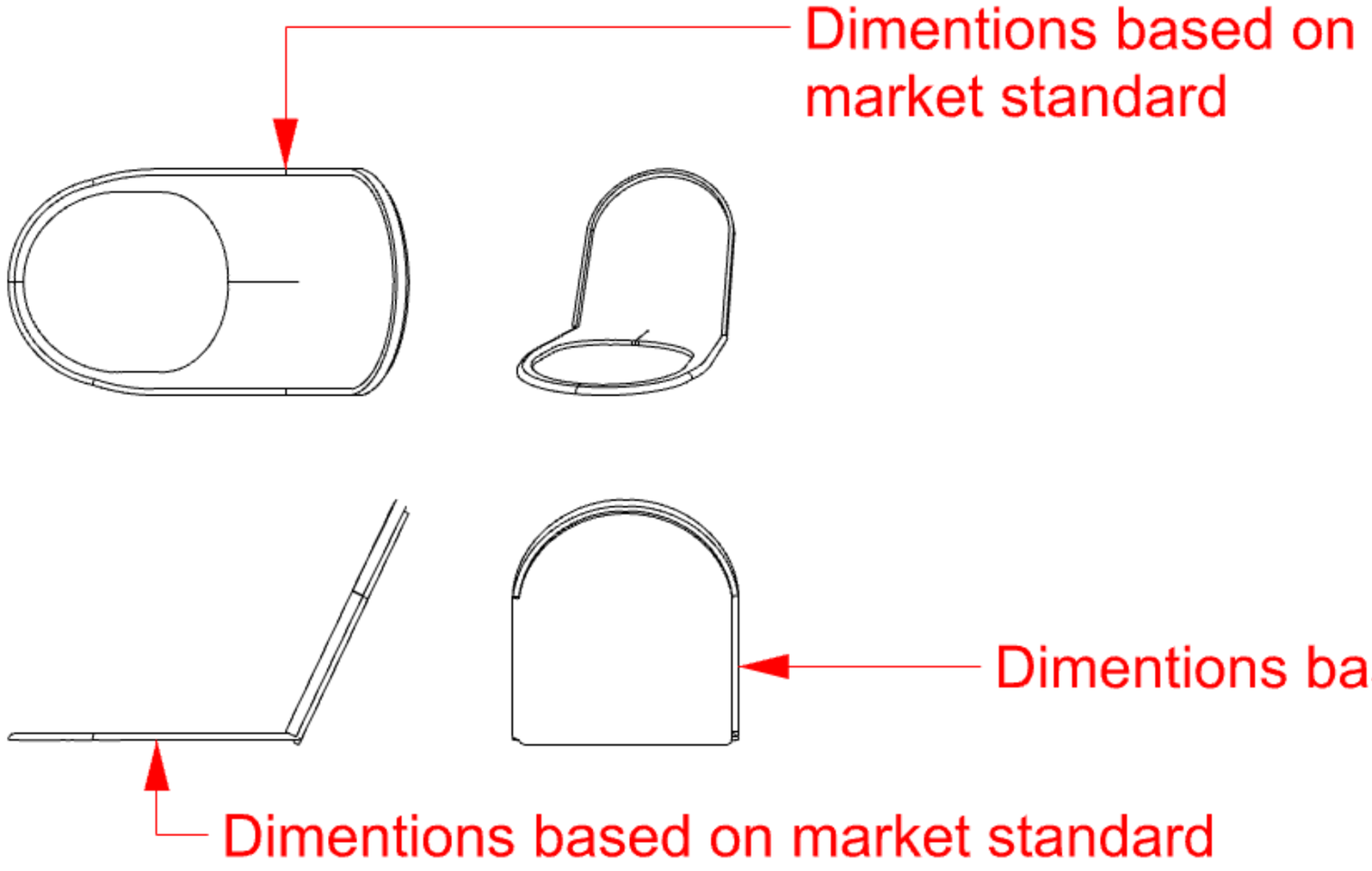
Polypropylene Box			
	All Dimensions in mm	Scale 1:1	Polypropylene
		Full Drawing	March 2024

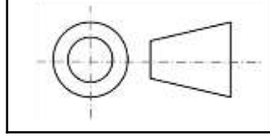


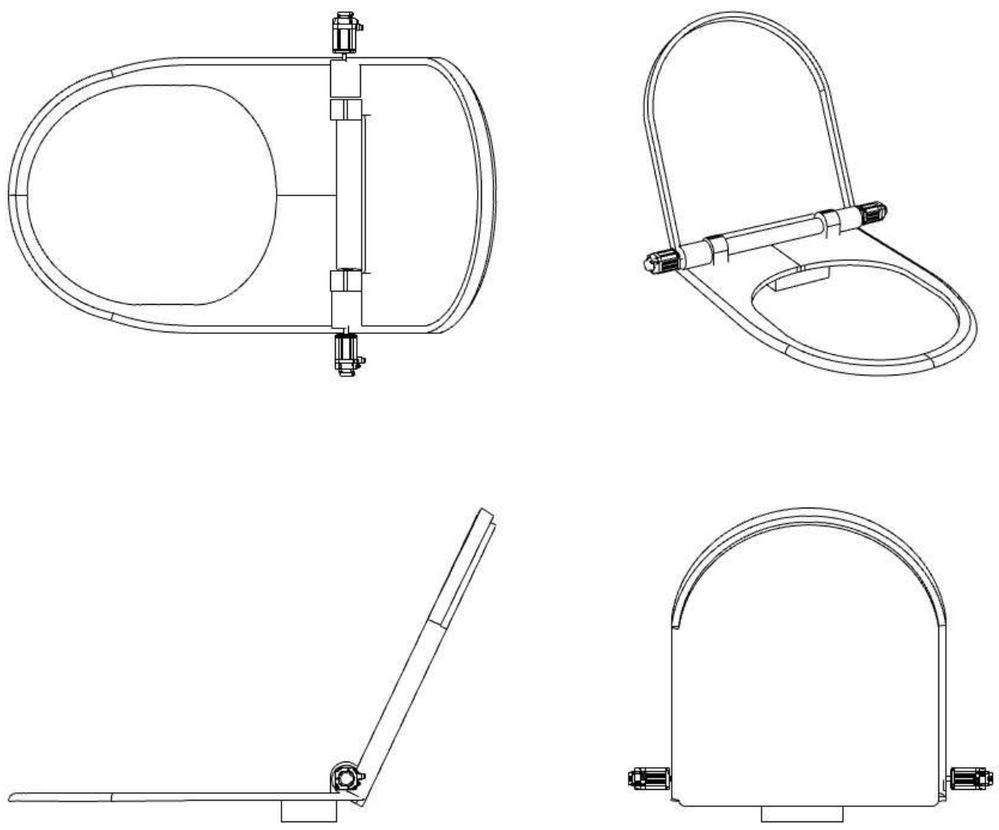
Stainless Steel Drum			
	All Dimensions in mm	Scale 1:1	Stainless Steel
		Full Drawing	March 2024



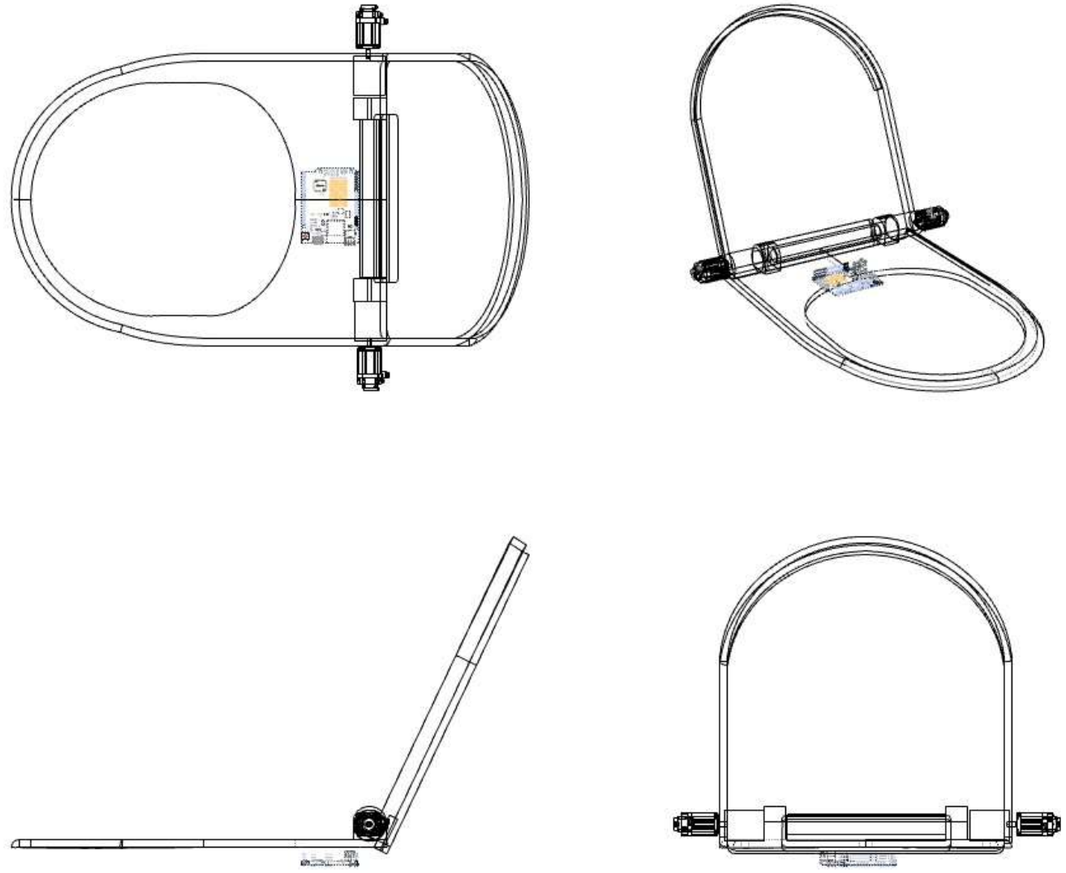
Toilet Seat Hinge			
	All Dimensions in mm	Scale 1:1	Stainless Steel
		Full Drawing	March 2024



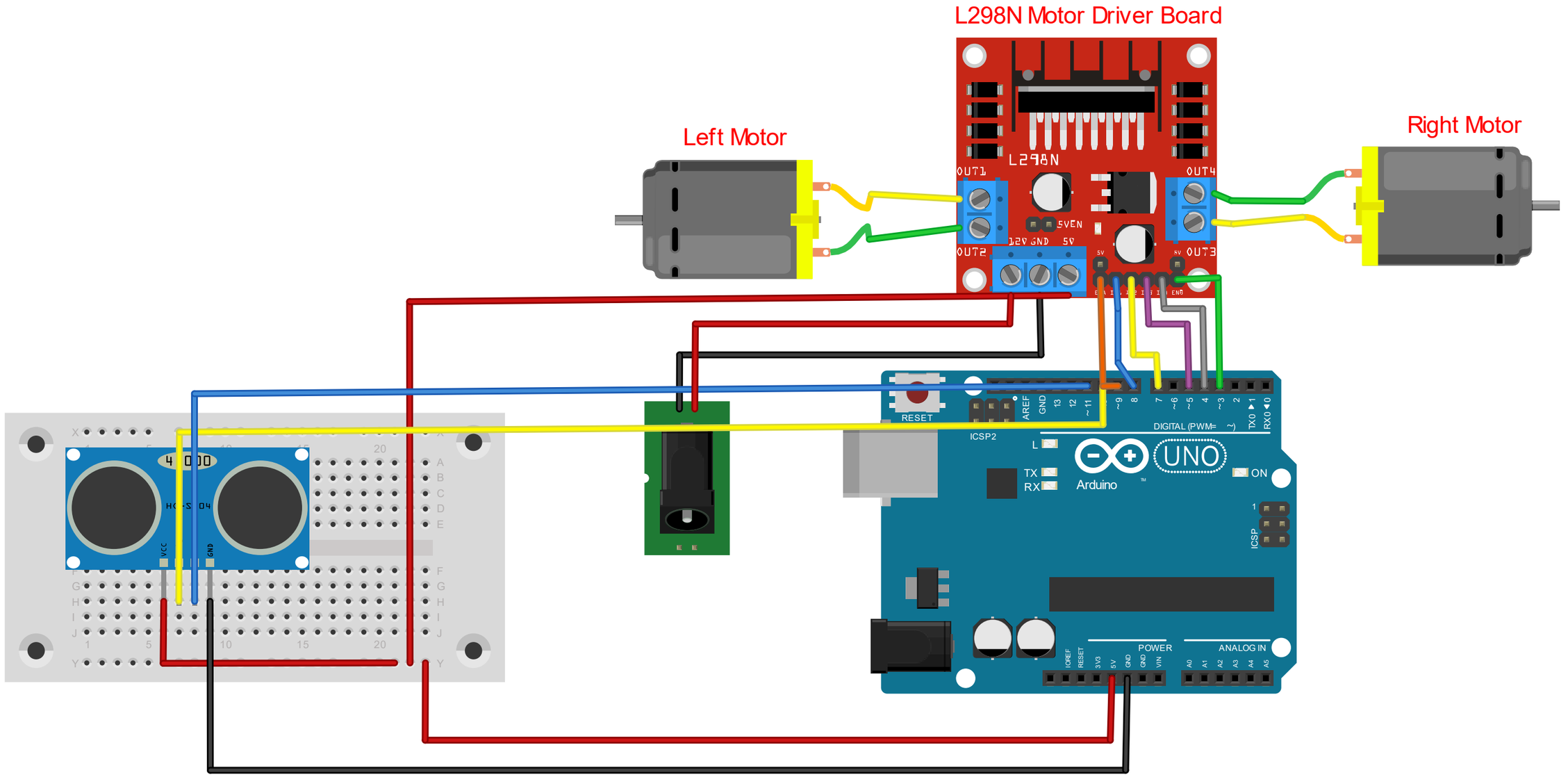
Toilet Seat Hinge			
	All Dimensions in mm	Scale 1:1	Polypropylene
		Full Drawing	March 2024



Assembled View (Without hidden details)			
	All Dimensions in mm	Scale 1:1	Polypropylene
		Full Drawing	March 2024



Assembled View (With hidden details)			
	All Dimensions in mm	Scale 1:1	Polypropylene
		Full Drawing	March 2024



This is the complete circuit diagram that I made and then followed to wire and assemble the electronics. In the actual electronics, I plan on soldering the pins on to a printed circuit board (PCB) and attaching the wires their for increased security and safety.

Planning for production: Code

Code for the Ultrasonic Sensor

```
// defines pins numbers
const int trigPin = 9;
const int echoPin = 10;
// defines variables
long duration;
int distance;
void setup() {
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  Serial.begin(9600); // Starts the serial communication
}
void loop() {
  // Clears the trigPin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin on HIGH state for 10 micro seconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);
  // Calculating the distance
  distance = duration * 0.034 / 2;
  // Prints the distance on the Serial Monitor
  Serial.print("Distance: ");
  Serial.println(distance);
}
```

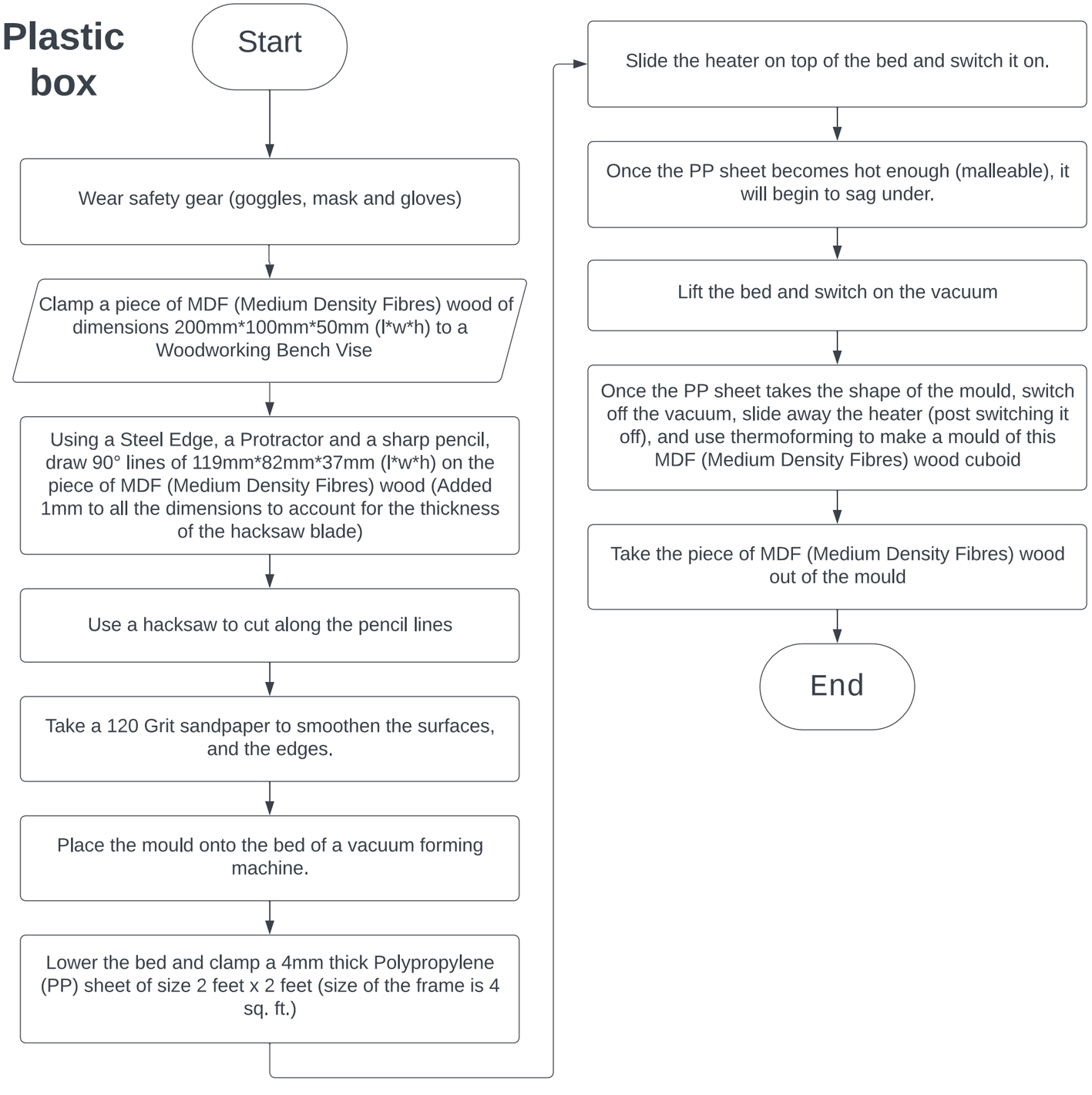
Code for the L298N Motor Driver Board

```
// This function lets you control spinning direction of motors
void directionControl() {
  // Set motors to maximum speed
  // For PWM maximum possible values are 0 to 255
  analogWrite(enA, 255);
  analogWrite(enB, 255);

  // Turn on motor A & B
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
  digitalWrite(in3, HIGH);
  digitalWrite(in4, LOW);
  delay(2000);

  // Now change motor directions
  digitalWrite(in1, LOW);
  digitalWrite(in2, HIGH);
  digitalWrite(in3, LOW);
  digitalWrite(in4, HIGH);
  delay(2000);

  // Turn off motors
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
}

// This function lets you control speed of the motors
void setup() {
  // Set all the motor control pins to outputs
  pinMode(enA, OUTPUT);
  pinMode(enB, OUTPUT);
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
  pinMode(in3, OUTPUT);
  pinMode(in4, OUTPUT);

  // Turn off motors - Initial state
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
}

void loop() {
  directionControl();
  delay(1000);
  speedControl();
  delay(1000);
}
```

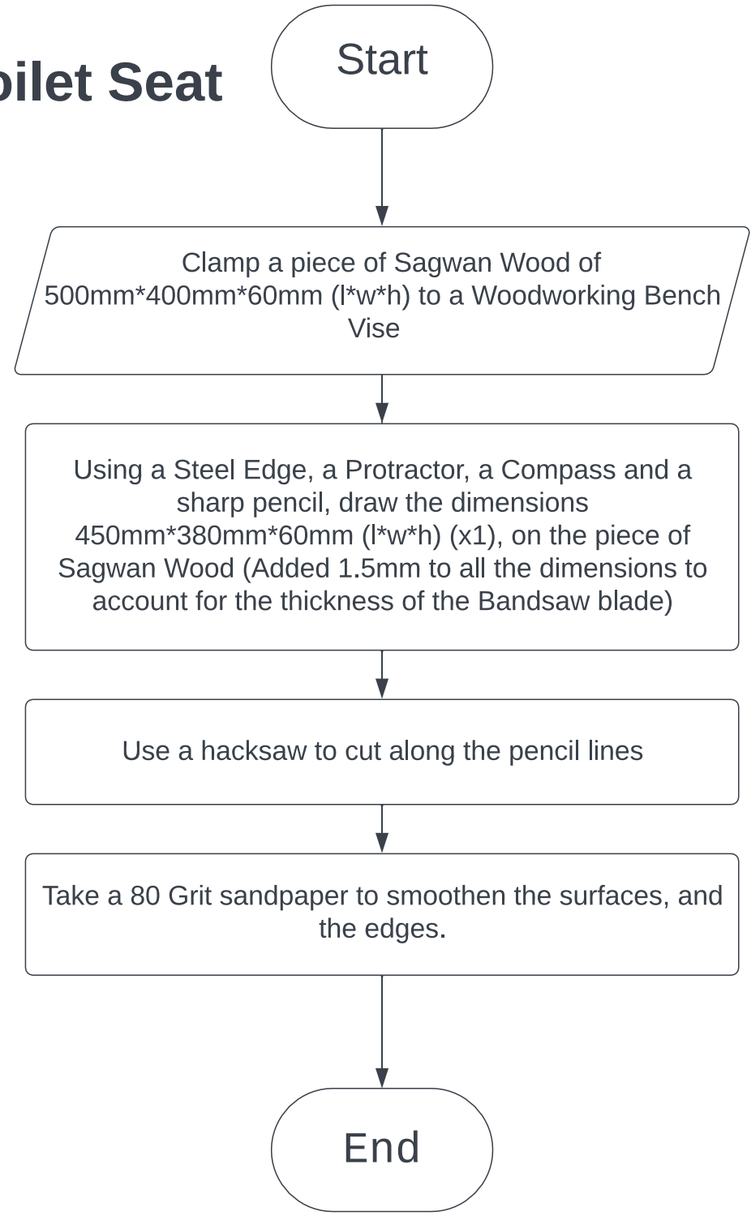
Combined code for both the Ultrasonic Sensor as well as the L298N Motor Driver Board, so that once the person enters a certain distance, the motors start to turn in opposite directions. The code can be found here (https://bit.ly/439GhTL)

Planning for production: Production flowcharts

Plastic box

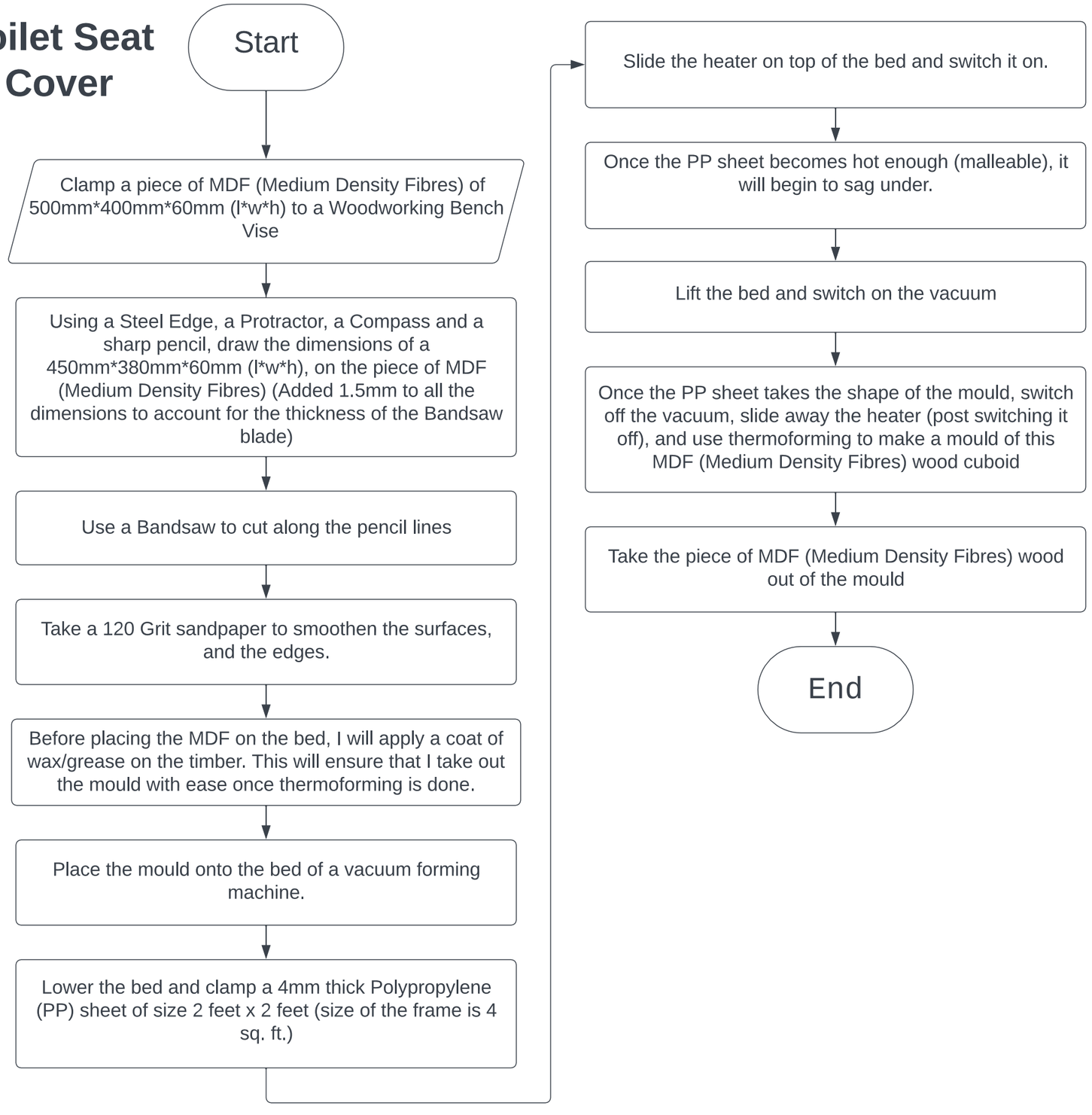


Toilet Seat

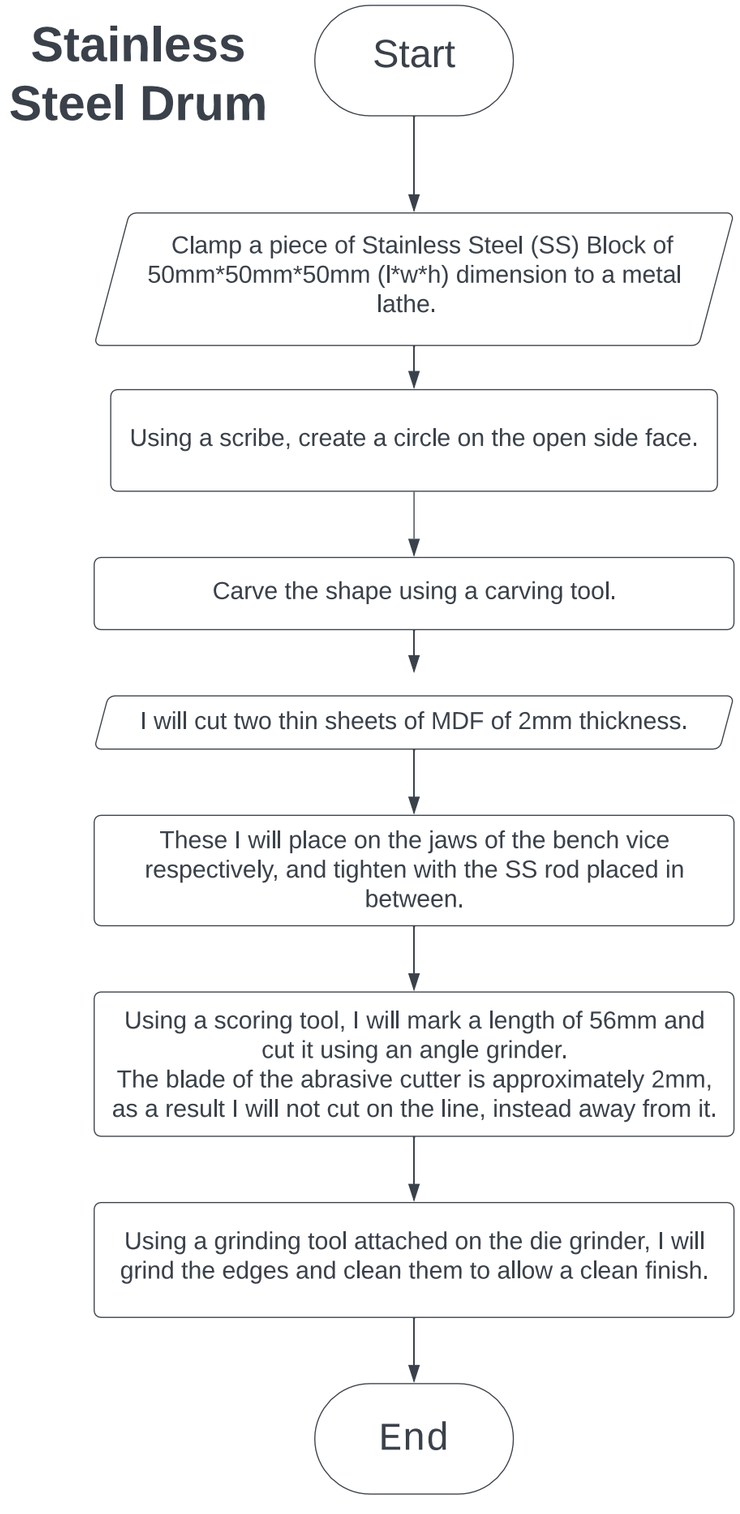


Planning for production: Production flowcharts

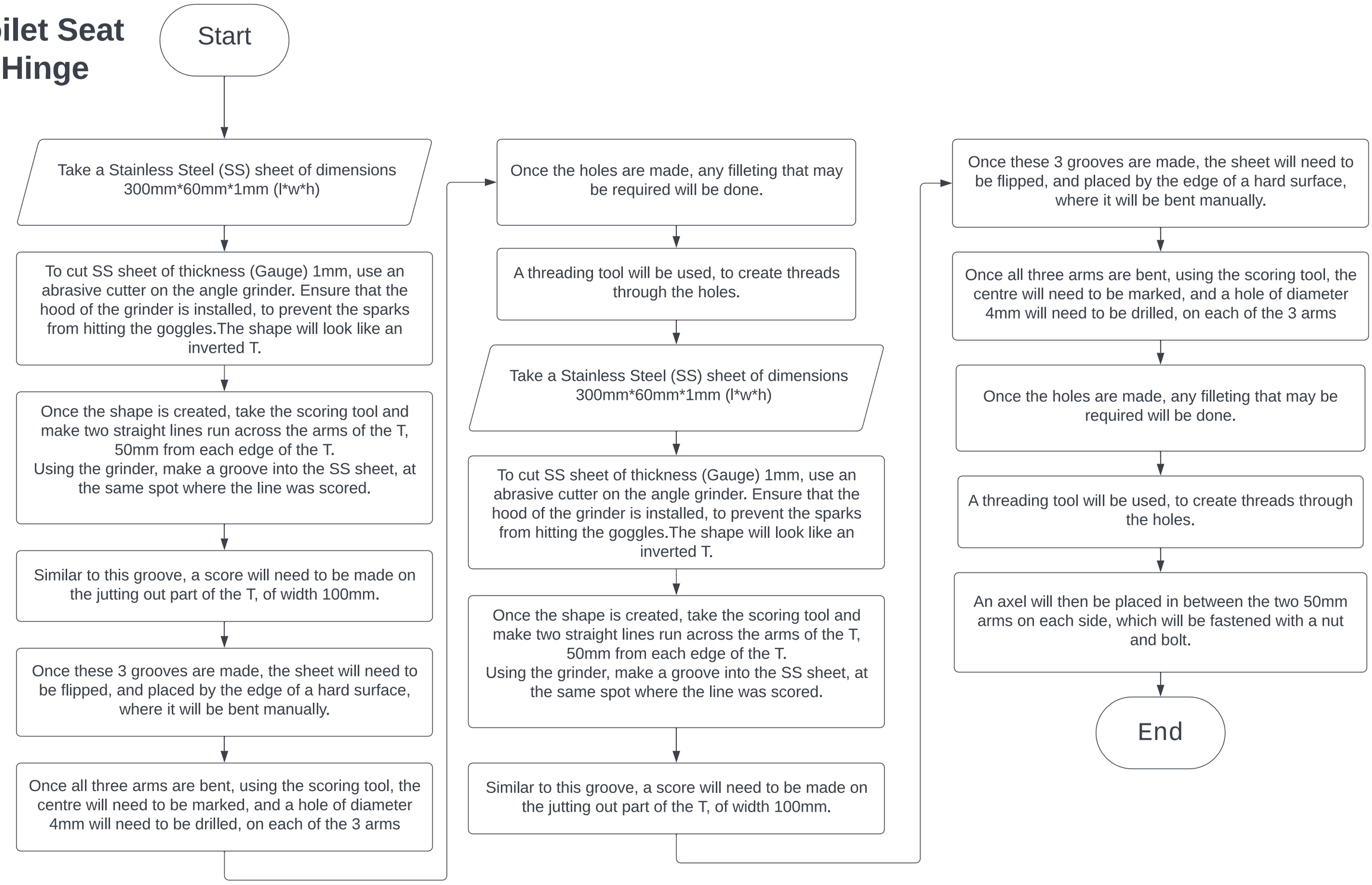
Toilet Seat Cover



Stainless Steel Drum



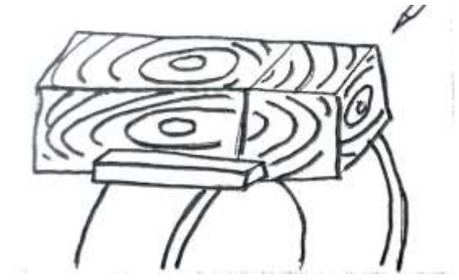
Toilet Seat Hinge



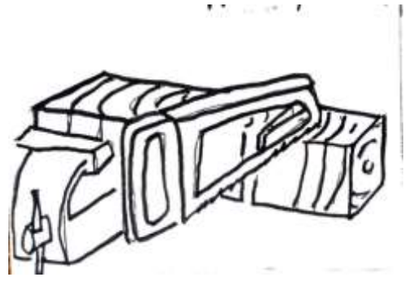
Planning for production: Daily log chart

Plastic Box

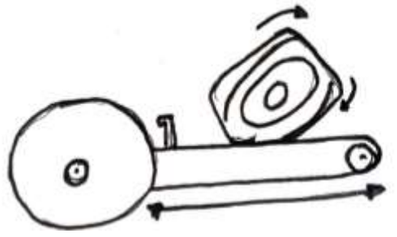
1) Clamp a piece of MDF (Medium Density Fibres) wood of dimensions 200mm*100mm*50mm (l*w*h) to a Woodworking Bench Vise



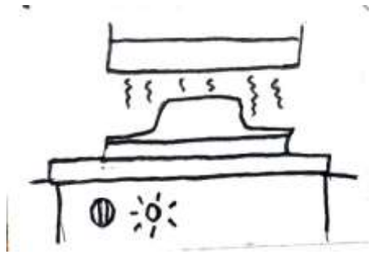
2) Using a Steel Edge, a Protractor and a sharp pencil, draw 90° lines of 119mm*82mm*37mm (l*w*h) on the piece of MDF (Medium Density Fibres) wood (Added 1mm to all the dimensions to account for the thickness of the hacksaw blade)



3) Use a hacksaw to cut along the pencil lines



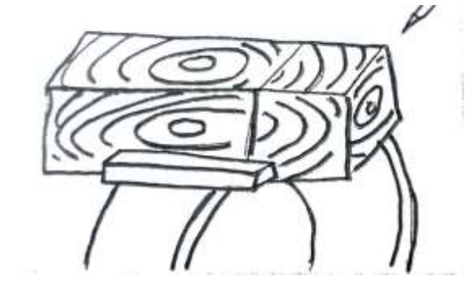
4) Take a 120 Grit sandpaper to smoothen the surfaces, and the edges.



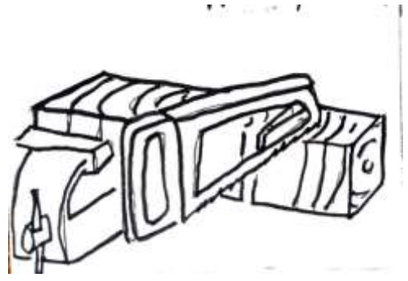
5) Place the mould onto the bed of a vacuum forming machine, lower the bed, place the PP sheet of thickness 4mm and clamp it in place. Slide the heater over and switch it on. As the sheet becomes malleable, it begins to sag. Lift the bed and switch on the vacuum
Once the PP sheet takes the shape of the mould, switch off the vacuum, slide away the heater (post switching it off), and use thermoforming to make a mould of this MDF.

Toilet Seat

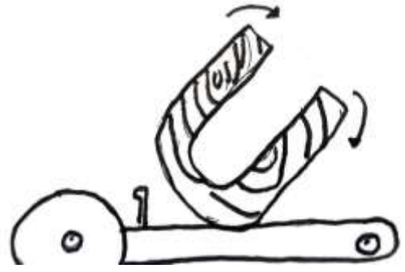
1) Clamp a piece of MDF (Medium Density Fibres) wood of dimensions 200mm*100mm*50mm (l*w*h) to a Woodworking Bench Vise



2) Using a Steel Edge, a Protractor and a sharp pencil, draw 90° lines of 119mm*82mm*37mm (l*w*h) on the piece of MDF (Medium Density Fibres) wood (Added 1mm to all the dimensions to account for the thickness of the hacksaw blade)



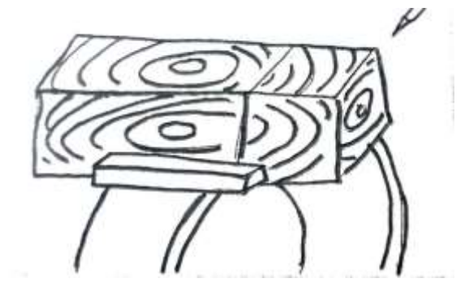
3) Use a hacksaw to cut along the pencil lines



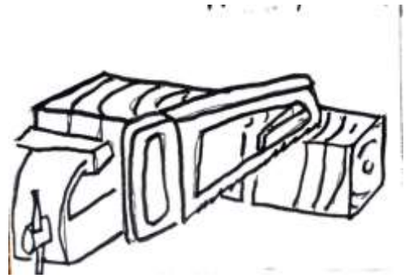
4) Take a sandpaper to smoothen the surfaces, and the edges.

Toilet Seat Cover

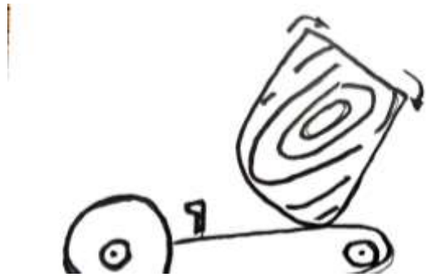
1) Clamp a piece of MDF (Medium Density Fibres) wood of dimensions 200mm*100mm*50mm (l*w*h) to a Woodworking Bench Vise



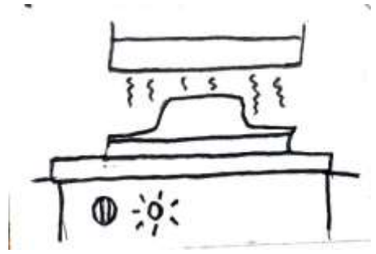
2) Using a Steel Edge, a Protractor and a sharp pencil, draw 90° lines of 119mm*82mm*37mm (l*w*h) on the piece of MDF (Medium Density Fibres) wood (Added 1mm to all the dimensions to account for the thickness of the hacksaw blade)



3) Use a hacksaw to cut along the pencil lines

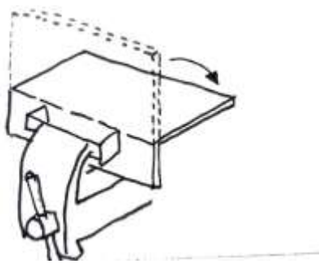


4) Take a 120 Grit sandpaper to smoothen the surfaces, and the edges.

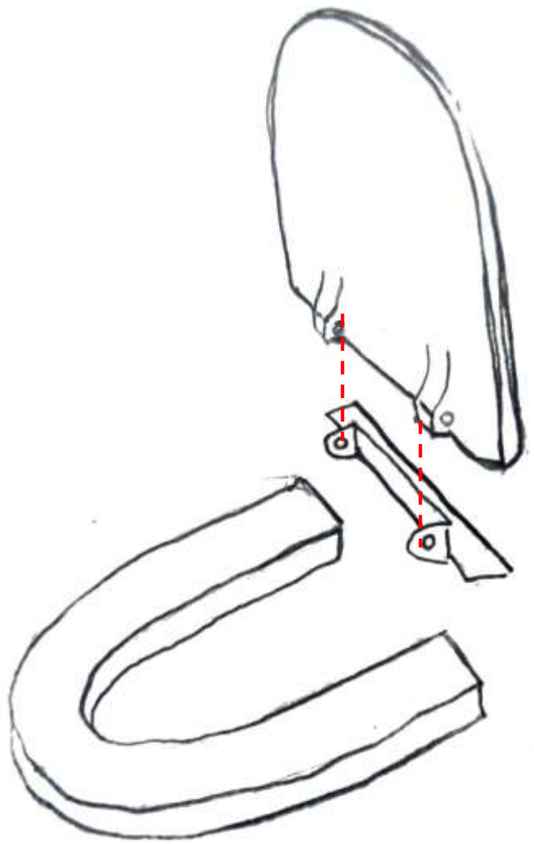


5) Place the mould onto the bed of a vacuum forming machine, lower the bed, place the PP sheet of thickness 4mm and clamp it in place. Slide the heater over and switch it on. As the sheet becomes malleable, it begins to sag. Lift the bed and switch on the vacuum
Once the PP sheet takes the shape of the mold, switch off the vacuum, slide away the heater (post switching it off), and use thermoforming to make a mold of this MDF.

Toilet Seat Hinge



1) Take a Stainless Steel (SS) sheet of dimensions 300mm*60mm*1mm (l*w*h). The shape will look like an inverted T. Once the shape is created, take the scoring tool and make two straight lines run across the arms of the T, 50mm from each edge of the T. Using the grinder, make a groove into the SS sheet, at the same spot where the line was scored. Once these 3 grooves are made, the sheet will need to be flipped, and placed by the edge of a hard surface, and be bent using a mallet.



This is what the exploded view of the assembled product will look like. This image contains the hinge, toilet seat, the cover and the plastic box.

Planning for production: Material analysis and selection, and quantity and cost listing

S. No.	Component	Material	Advantage	Disadvantage	Choice	Reason For Choice
1	**Plastic box, Toilet Seat Cover**	MDF (Medium Density Fibers)	Cheap, easy to cut and shape	Can crack and split, weaker than wood, does not take screw threads easily		When thermoforming, I do not need a wood with a high density, but I do need a wood that is easy to cut.
		Pine Wood	Cheap, lightweight, responds to humidity changes	More knots, may bleed through		
2	**Plastic box, Toilet Seat Cover, Toilet Seat Hinge**	Polypropylene (PP)	Low density, chemical resistance, low moisture absorption	Extremely flammable, suffers from chain degradation		Due to it's low water absorbant capibilities, and able to thermoform.
		Acrylic	Has outstanding strength and stiffness. Readily available and easy to cut	Brittle, prone to scratches		
		High Impact Polystyrene (HIPS)	Lightweight, good dimensional stability,	Vulnerable to degradation by many chemicals, poor tensile strength, not biocompatible		
3	**Stainless Steel Drum, Toilet Seat Hinge**	Stainless Steel (SS)	Corrosion resistant, high stability and strength	Catches dirt, expensive		Due to the fact that it is corrosion resitant, that means that if the drums get wet, they will not rust and need to be replaced
		Mild Steel (MS)	Cost Effective, Strong, Less likely to warp	Heavy, Poor resistance to Corrosion		
		Aluminium (AL)	Flexible, Durable, Impact Resistant, Sturdy	Requires Argon gas welding, which is not easily available.		
4	**Toilet Seat**	Sagwan Wood	Durable, attactive grains, apt for intricate designs	Difficult to glue to screw threads, expensive		For the toilet seat itself, we require a wood with a high density, so that the consumer is comfertable
		Mahogany Wood	Apt for intricate designs, attractive grains, durable, grains hold screw threads tightly	Expensive, surface needs treatment		
		Oak Wood	Durable, Water-Resistant, Shrinking and Warping Resistant	Heavy weight, expensive		
5	**Microproccesor**	Arduino Uno	Inexpensive Hardware, Cross Platform Support	Lack of Multitasking, Limited Support for Programming Languages		We choose the Arduino Uno due to the fact that it is inexpensive and does not require external memory
		Raspberry Pi	Vast Peripheral Support, Supports all type of Codes, Can be Used as a Portable Computer	No internal storage, overheats very easily, high maintainence		
6	**Range Detection Sensor**	Ultrasonic Sensor	Consume lower current, works well in dim places, not affected by object color and transparency	Limited detection range, low resolution and slow refresh rate		We use this piece of elecronics as it is extremely reliable and can work in dark enironments.
		Infrared Distance Sensors	Small form factor, secured communication through a line of sight	Limited range of measurement, affected by environmental conditions and hard objects		
		Laser Distance Sensors (LIDAR)	Ability to measure 3D structures, Fast update rate	Higher cost of operation, harmful to the naked eye		
7	**Motor**	DC Motor	Good speed control, high torque, no harmonic effect	They have high startup power, cannot operate in explosive and hazard conditions		A DC motor shall be used to the fact that it can spin 380° and can turn our SS drum
		Servo Motor	Low-speed operation is stable, water resistant	Can only move from 0° to 180°, high cost		

Planning for production: Quantity and cost listing

S. No.	Material	Size	Standard Sizes	Quantity	Price (Market / My Req)
1	**MDF (Medium Density Fibres)**	200mm*100mm*50mm (l*w*h)	8' x 4' x 1"	x1	₹3400/- ₹920/-
2	**MDF (Medium Density Fibres)**	100mm*100mm*2mm (l*w*h)	8' x 4' x 2mm	x1	₹480/- ₹7/-
3	**Stainless Steel (SS) sheet**	600mm*60mm*1mm (l*w*h)	8' x 4' x 1mm	x1	₹2387/- ₹596/-
4	**Polypropylene (PP) sheet**	609.6mm*609.6mm*4mm (l*w*h)	3' x 3' x 4mm	x3	₹800/- ₹643/-
5	**Sagwan wood**	500mm*400mm*60mm (l*w*h)	8' x 9" x 1.5'	x1	₹1743/- ₹348/-
6	**LDPE Plastic Tubing Roll**	1mm thick		x1	₹150/- Spare available in the lab
7	**Arduino Uno**			x1	₹265/- Spare available in the lab
8	**HC-SR04-Ultrasonic Sensor**			x1	₹58/ Spare available in the lab
9	**298N DC Motor Driver**			X1	₹93/ Spare available in the lab
10	**9V DC Motors**			x2	₹12/ Spare available in the lab
11	**9V Batteries**			x2	₹21/ Spare available in the lab

The total cost of materials = INR 2550/- (£24 – 11 March ‘24)
To decrease the cost, lower quality wood to be used. Or we can buy materials in bulk

Product realization

Firstly, I used a pre-bought toilet seat cover to measure the standard toilet seat dimensions. I then traced this out on Pine wood.

Then I used a band saw to cut the outline of the toilet seat. Since I did not have a piece big enough to make the whole toilet seat on, I proceeded to make 2 halves of the toilet seat.

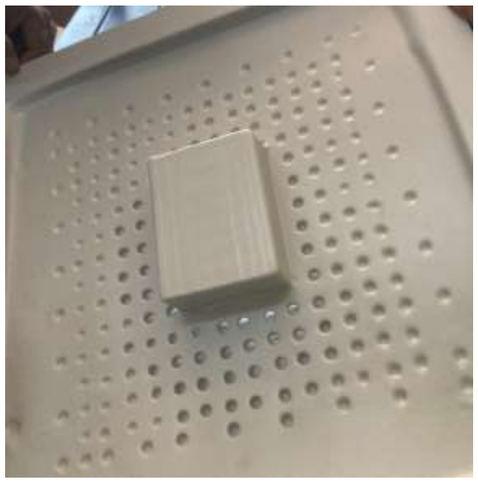
After making the two halves, I used a drill to make holes in each half. This was due to the fact that I could then join both of the halves using a dowel joint.

To make the dowels, I used rectangular prisms and planed them to get a relatively circular cylinder.

This is what the final version of the dowel looked like. To ensure that the cylindrical dowels would not be loose, I reinforced these joints using Fevicol SH.

Due to the fact that Pine wood will splinter, which may harm the user, I have decided to move forward with using Sagwan Wood

I did not have a big enough piece of Sagwan wood to make my toilet seat out of, so I divided my seat into 2 halves, and used a biscuit joint to fasten both of the halves together.



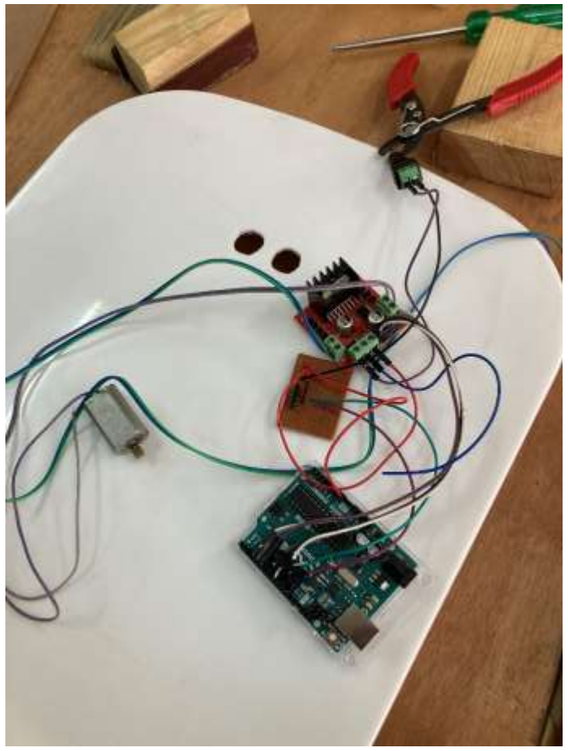
After making the toilet seat I moved onto making the plastic box that would hold all of my electronic components.

For this I created a mold out of wood and proceeded to vacuum form the required shape.

After I extracted the wooden mold from the PP sheet, this was the shape I was left with.

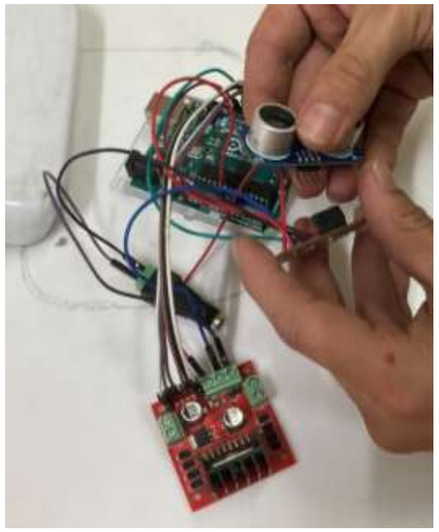
After removing the excess plastic and sanding the box down to get a clean finish, this is the product that I was left with.

To make sure that the Ultrasonic Sensor has a clear path of vision, I drilled 2 holes of the diameter of the ultrasonic sensor into the toilet seat cover.



I tested my circuit once again, after extending the wires to the necessary length.

After doing this I attempted to secure the electronic components on the toilet seat, but realized that I would need a hole in my box for the power cable.

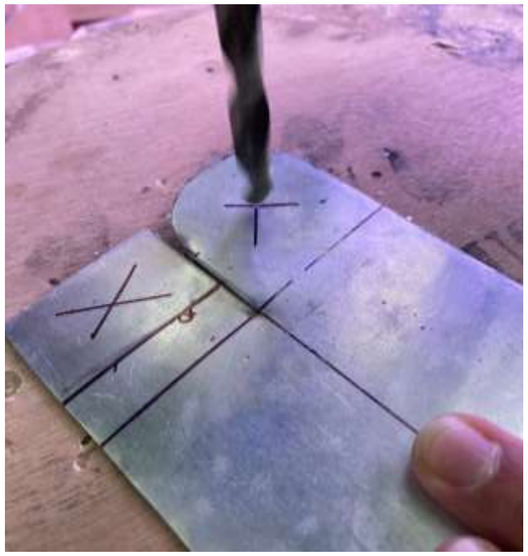


Once I had marked the place where the box would go, and I had created a hole for the power cable, I put my electronics in the box

This is the final electronics once it was secured in the box.

The thermoforming machine that we have in school only has a bed of 18 inches*18inches, and since I would not be able to make the toilet seat cover using this machine, I decided to use the toilet seat cover that I had bought. This would save me both resources and time.

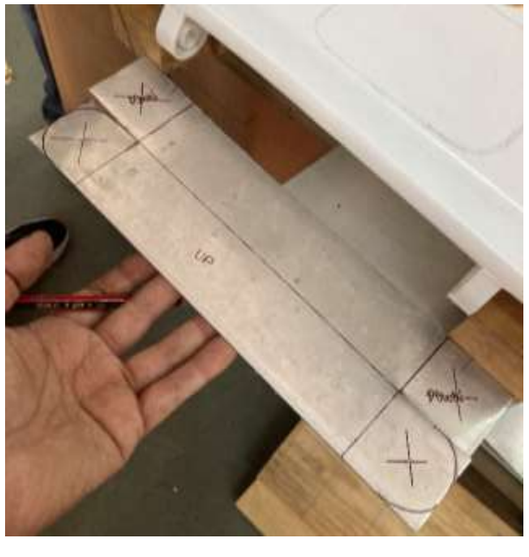
To create the hinge that would connect the toilet seat and the cover, I took some assistance and drew out the correct dimensions on a Stainless Steel sheet



I used a stand-alone drill to drill holes in the hinge where it could be fastened on to the seat and the cover.

After making these dimensions, I cut the sheet out to make the hinge.

I then clamped this piece to a woodworking vice and used a mallet to bend it to the correct angle.



After doing this I compared it with the actual dimensions to see if I needed to make any changes.

This is what the hinge attached to the seat finally looked like.

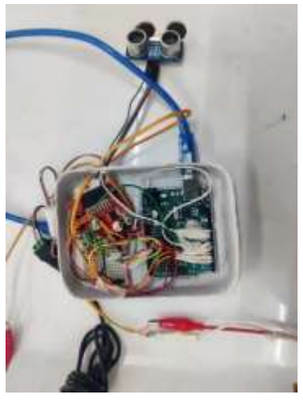
After this I sanded the corners of my seat, to improve the movement of the toilet seat.

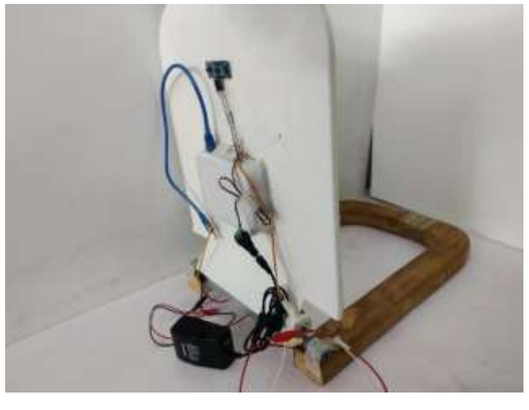
Then I cut a threaded rod to the dimension that I needed, to fit the toilet seat cover on the hinge.

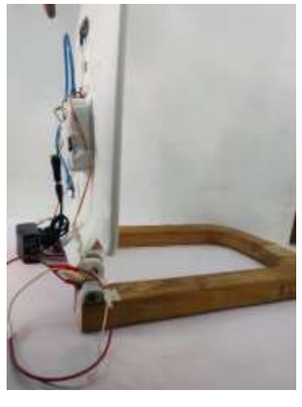
Once I inserted the threaded rod onto the hinge, I realized their was a little bit of an excess, which I then cut off.

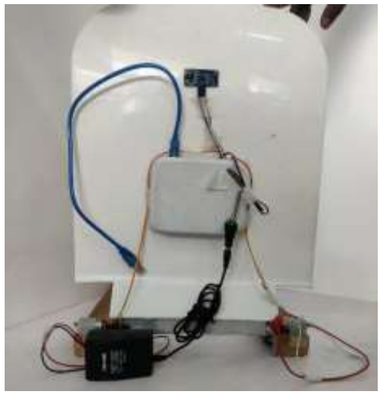
This is what the final hinge looked like

Final outcome

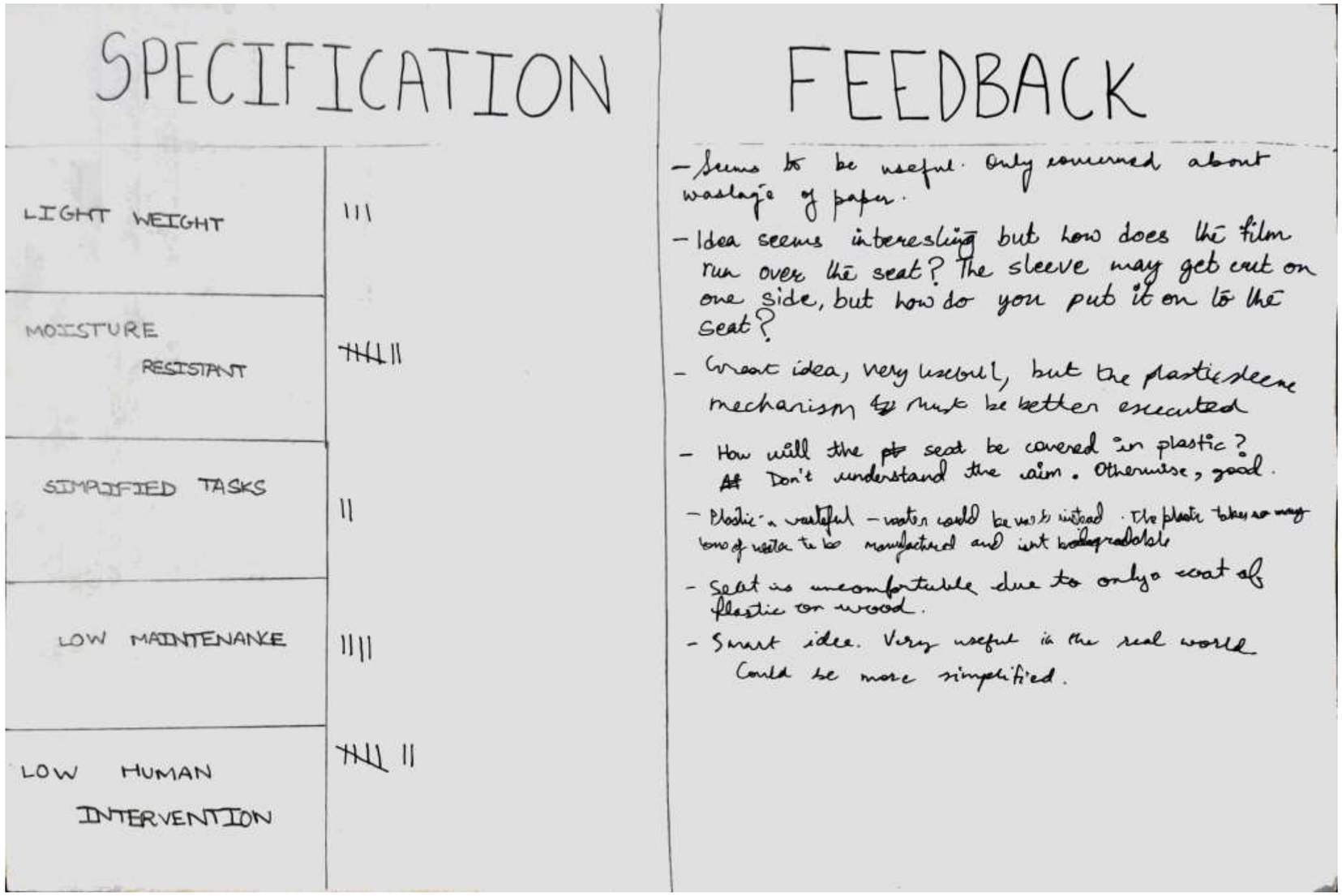








Testing and Evaluation: User testing



SPECIFICATION	
LIGHT WEIGHT	III
MOISTURE RESISTANT	~~IIII~~ II
SIMPLIFIED TASKS	II
LOW MAINTENANKE	IIII
LOW HUMAN INTERVENTION	~~IIII~~ II

FEEDBACK

- Seems to be useful. Only concerned about wastage of paper.
- Idea seems interesting but how does the film run over the seat? The sleeve may get cut on one side, but how do you put it on to the seat?
- Great idea, very useful, but the plastic sleeve mechanism must be better executed
- How will the seat be covered in plastic? Don't understand the aim. Otherwise, good.
- Plastic's a wasteful – water could be used instead. The plastic takes so many tons of water to be manufactured and isn't biodegradable
- Seat is uncomfortable due to only a coat of plastic on wood.
- Smart idea. Very useful in the real world. Could be more simplified.

To test my product against the given specifications, I decided to take a user survey. In the survey, users were allowed to test the product themselves and decide whether the product met the specifications. They also gave feedback about their experience and suggestions regarding the improvements that could be made.

Feedbacks given by different users:

- Seems to be useful. Only concerned about wastage of plastic

- Idea seems interesting but how does the film run over the seat? The sleeve may get cut on one side, but how do you put it to the seat?

- Great idea, very useful, but the plastic sleeve mechanism must be better executed

- How will the seat be covered in plastic? Don't understand the aim. Otherwise, good

- Plastic's wasteful – Water could be used instead. The plastic takes so many tons of water to be manufactured and isn't biodegradable.

- Seat is uncomfortable due to only coat of plastic on wood

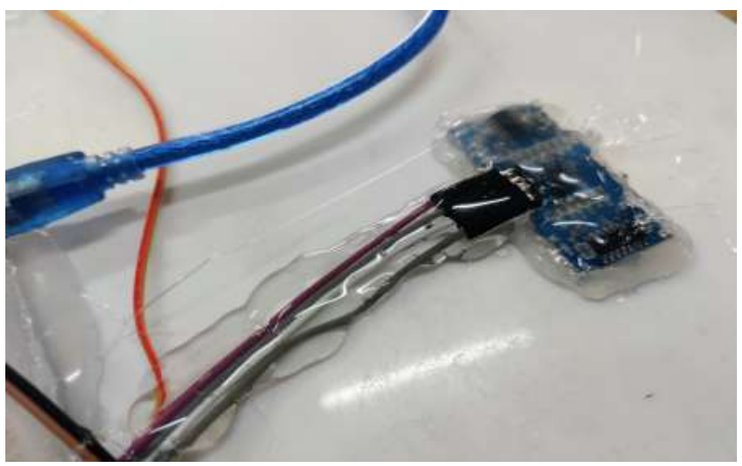
- Smart idea. Very useful in the real world. Could be more simplified.





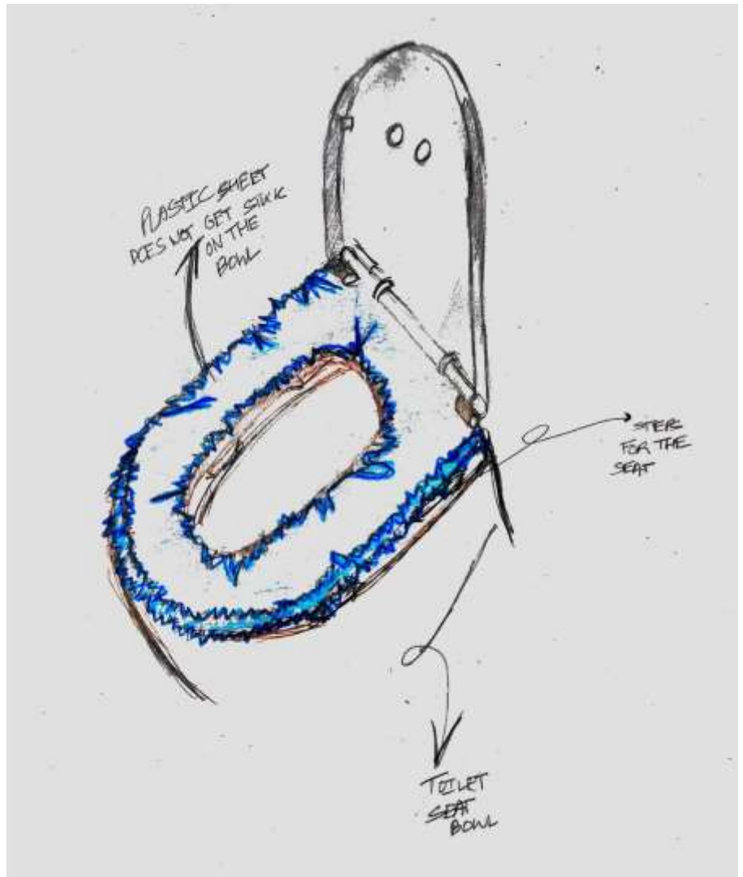
Refinements

Physical



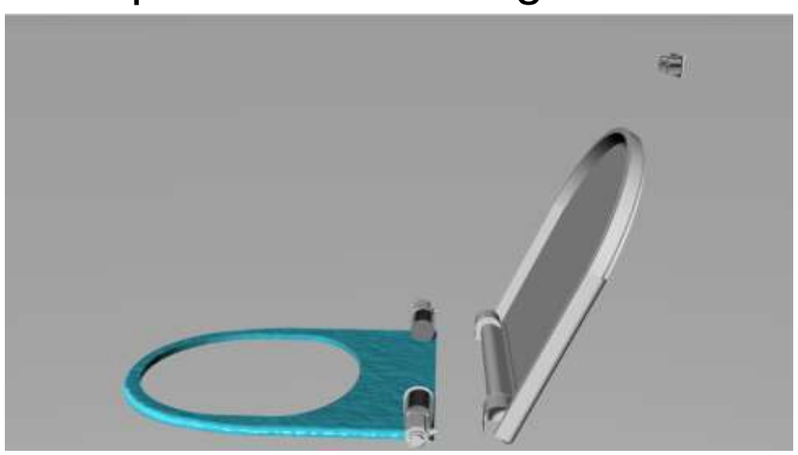
As a physical improvement , I coated the electronics, so that the electronics are safe from water and do not get damaged

Drawing



As an improvement in the form of a drawing, I drew steps under the toilet seat to help the plastic sheet not get stuck on the toilet bowl while it is being moved.

Computer Aided Design



As an improvement in the form of CAD (Computer Aided Design), I separated the toilet seat from the toilet cover. This lets the plastic sheet cover the seat and not get stuck on the hinge.