A Minor Project Report on

# "SMACBOT"

**Bachelor of Engineering in**

Mechanical Engineering

**Submitted by**


| | |
|---|---|
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Under the Guidance of

*Prof. Praveen Petkar*

**K L E Society's**

**KLE Technological University**

**HUBLI-31**

**School of Mechanical Engineering**

KLE Technological University
Creating Value
Leveraging Knowledge

# CERTIFICATE

This is to certify that Capstone Project entitled **"SMACBOT"** (Smart Floor Mopping Device) submitted by **Team C7 to** the **KLE Technological University**, Hubli-580031, towards partial fulfillment for the award of the degree of Bachelor of Engineeringis a bona-fide record of work carried out by him/her under our supervision. The contents of project report, in full or in parts, have not been submitted to any other institute or university for award of any degree or diploma.

| | |
|---|---|
| Prof. Praveen Petkar | Dr. B. B. Kottureshettar |
| **Guide** | **Head of department** |
| **Name of the Examiners** | **Signature with date** |

1.
2.

# ACKNOWLEDGEMENT

The successful completion of any task would be incomplete without mentioning the people who made it possible and whose guidance and encouragement has made our efforts successful.

At the outset, we would like to express our deep sense of gratitude for our guide **Prof. Praveen Petkar** for making this project report successful through their invaluable guidance at every stage of the project report.

We also thank **Dr. B. B. Kottursheettar** for his encouragement in undertaking the task of this project.

We express our sincere regard and gratitude to our project coordinators **Prof Nagaraj Ekbote, and Prof. Shridhar M,** School of Mechanical Engineering, KLE Technological University, Hubli

We also thankful to all faculty members of the Mechanical Engineering Department of KLE Technological University, for helping us directly or indirectly in different stages of our project work.

**Students signature**

**(Team C7)**

# MINOR PROJECT TEMPLATES

**Phase wise expectations and tasks:**

**Design Phase:**

| 1. Refined problem statement | | *(Tick mark the cell once each activity is completed)* |
|---|---|---|
| 1.1 | Identifying end users (Customers) | |
| 1.2 | Identify customer needs | |
| 1.3 | Analyzing the needs | |
| 1.4 | Requirements List | |
| 2. Product benchmarking | | |
| 2.1 | Studying and exploring competitive products | |
| 2.2 | Patent search | |
| 2.3 | Literature survey | |
| 3. Design Specifications | | |
| 3.1 | Objectives | |
| 3.2 | Constraints | |
| 3.3 | Objective tree (affinity diagram) | |
| 3.4 | Design Specifications | |
| 4. Concept generation | | |
| 4.1 | Defining Functions | |
| 4.2 | Morphological chart | |
| 4.3 | Generating design alternatives | |
| 4.4 | Selecting best alternatives (Pugh chart) | |
| 5. Design | | |
| 5.1 | 3D Model | |
| 5.2 | Assembly models | |
| 5.3 | 2D drawing | |
| 5.4 | Design Calculations | |
| 6 Prototype Planning | | |
| 6.1 | Raw materials | |
| 6.2 | Bill of Materials | |
| 6.3 | Joining techniques/ methods | |
| 6.4 | Flow Chart | |
| 6.5 | Sub-Assembly Planning | |

**Phase 1**

## 1 Refined problem statement

1.1 Identifying end users (Customers)

- Determine who the customers are for your product

1.2 Identify customer needs

- Determine what information should be gathered from customers, their needs, expectations

1.3Analyzing the needs

- Determine how that information should be gathered

| Customer: Nalini S. | Interviewer(s): Supreet M. | Date: 02/04/2021 |
|---|---|---|
| **Question/Prompt** | **Customer Statement** | **Interpreted Need/ Expectations** |
| **Typical uses** | Removing coffee/tea stains from the floor is difficult. | Proper Scrubbing of the floor is to be ensured |
| | I mop my floor with Phenyl added water. | Phenyl added water cleans better over normal water. |
| **Likes-current methods followed(traditional techniques)** | I can stress on more dirt accumulated areas. | Dirty area of the floor is to be cleaned effectively |
| | Visual inspection of the whole process will be available. | Process need to be visually inspected |
| **Dislikes-current methods followed(traditional techniques)** | Consumes a lot of time if the area is large. | Time span of the whole process should be reduced. |
| | It requires a lot of physical work | Minimal amount of physical work should be made possible |
| **Suggested Improvements** | Shouldn't damage the marble/granite flooring | Proper use of phenyl to be supervised |
| | Floor to be dried in short period of time | Quick dry. |

| Customer: Ramesh I. | Interviewer(s): Vikhyat G. | Date:06/04/2021 |
|---|---|---|
| **Question/Prompt** | **Customer Statement** | **Interpreted Need/ Expectations** |
| **Typical uses** | Corners, Area under furnitures end up not being well cleaned. | Every Part of the floor must be cleaned. |
| | Disinfectants should be used to clean the floor. | Propr disinfectant to be made sure |
| **Likes-current methods followed(traditional techniques)** | I would rather quick wipe my floor with mop to save time | shortly effective method to be used for time saving |
| | I prefer warm water over cold water. | Proper water temperature to be maintained. |
| **Dislikes-current methods followed(traditional techniques)** | Consumes lots of water | Water consumption should be reduced. |
| | Excessive use of Phenyl leads to damage on the floors. | Optimum amount of chemical to be used. |
| **Suggested Improvements** | Should consume less amount of time with effective cleaning. | Quick and effective cleaning to be maintained. |
| | The device must be easy to handle even for a common man. | User friendly and easily controllable. |

### 1.4 Requirements List

| Customers | Requirements |
|---|---|
| 1 to 6 | 1. Quick and effective cleaning. |
| | 2. Proper Disinfectant. |
| | 3. User friendly |
| | 4. Quick dry |
| | 5. Should not corrode / decolourize the floor. |

**Phase 2**

## 2. Product Benchmarking

2.1 Studying and exploring competitive products

| Products (Images or name) | Specifications | Cost | Advantage | Limitations | Functions |
|---|---|---|---|---|---|
| iBell Robotic Vacuum Cleaner  | **Name** iBell Robotic Vacuum Cleaner **Dimensions** 436 X 368 X 11.8 **Battery Capacity** 3200mAh Wi-Fi 2.4GHz 802.11 b/g/n Running Time 60-130 minutes **Weight** 3.6kg **Rated Power** 33W **Working Noise** ≤70dB (Standard mode) | ₹16,240 | Effective, independent, all-purpose cleaning<br><br>Decent battery life<br><br>Very good app and features<br><br>Laser Detect System for good navigation | Needs care and regular cleaning<br><br>Doesn't reach edges and narrow gaps<br><br>Can't replace manual vacuuming and mopping entirely | |

| | | | | | |
|---|---|---|---|---|---|
| EUFY by Anker<br>  | Max Power Consumption 27W<br><br>Battery Li-Ion<br><br>Product Dimensions 32.5 X 32.5 X 7.2<br><br>Product weight 2.7 kgs | ₹14,999 | Moves quickly and has no trouble switching between floor Easy to set up and use<br><br>Compact design with two large, spinning mopping pads<br><br>Features a Hand Mode to clean types<br><br>Eight floor-cleaning modes | No app or voice control<br><br>Doesn't always avoid area rugs and carpeting | |

| | | | | | |
|---|---|---|---|---|---|
| 3 ECOVACS Deebot 500<br>  | Dimensions: 33.2 X 33 X. 7.9<br>**Weight**: 4.85 lbs<br>Battery Type: Lithium Ion | ₹13,900 | Three mopping modes<br>Automatically recognizes and avoids carpet<br>Can clean in sequence with select Roomba robot vacuums | Too big for cleaning in tight spots in bathrooms and kitchens | |

**2.2 Patent search**

| Patent Name/ Number/ Date | Information |
|---|---|
| Robotic vacuum cleaner<br>US10729297B2<br>Publication Date: 04/08/2020 | A robotic vacuum cleaner having a nozzle inlet facing a surface to be cleaned, and a rotatable side brush. The rotatable side brush has bristles extending substantially in parallel with the surface to be cleaned, and the nozzle inlet includes a frame structure forming an opening, the opening being arranged in fluid communication with a debris receptacle. The bristles extend over a side portion of the nozzle inlet. The frame structure has a base portion extending substantially in parallel with the surface to be cleaned. The base portion extends at a first level. The frame structure at the side portion extends substantially in parallel with the surface to be cleaned at a second level. The first level is arranged closer to the surface to be cleaned than the second level. |
| Cylindrical robotic vacuum<br>US9521934B1<br>Publication Date: 20/12/2016 | A robotic vacuum wherein the housing of the system is cylindrical in form with two wheels of diameter larger than the diameter of the housing supporting the housing on either end. Larger wheels permit the device to more easily travel over small bumps or obstacles and changes in elevation. Furthermore, the design requires less power to drive the housing, so more energy is available for the primary function of vacuuming. |

**Phase 3**

## 3. Design Specifications

### 3.1 Objectives

| Objectives | |
|---|---|
| Less time consumption | Quick Drying |
| Eco-Friendly | Cost Effective |
| User Friendly | Less Usage of water |
| No harsh treatment on floor | Battery Powered |
| Optimum use of chemicals (disinfectants) | Notifying once the work is completed |

### 3.2 Constraints

| Constraints | |
|---|---|
| Water consumption | cleaning dry stains |
| Controlling Movement of device | Controlling release of water during the movement |
| Water resistance | |

### 3.3 Objective tree (affinity diagram)

| O# | Objectives | First level objectives | Second level objectives | Third level objectives |
|---|---|---|---|---|
| 1 | Safety | ● | | |
| 2 | device safety | | ● | |
| 3 | water proof | | | ● |
| 4 | rigid frame | | | ● |
| 5 | liability litigation | | | ● |
| 6 | mode of cleaning | ● | | |
| 7 | brushing | | ● | |
| 8 | scrubbing | | ● | ● |
| 9 | wiping | | ● | ● |
| 10 | drying | | ● | |
| 11 | maintenance | ● | | |
| 12 | battery maintenance | | ● | |
| 13 | water management | ● | | |
| 14 | Refilling regularly | | ● | |
| 15 | Using clean water | | ● | |
| 16 | brush replacement | | ● | |
| 17 | using disinfectant | | | ● |
| 18 | functionality | ● | | |

| | | | | |
|---|---|---|---|---|
| 19 | control flow flow | | ● | |
| 20 | operating specification of scrubber | | | ● |
| 21 | notification of cleaning | | ● | |

**Objective tree:**

### 3.4 Design Specifications:

| Si. | Engineering Specifications | Units |
|---|---|---|
| 1 | Overall dimensions | Millimeter |
| 2 | Water temperature range | Celsius |
| 3 | Speed of bush /scrubber | rpm |
| 4 | Amount of water used | Cubic meter |
| 5 | Time consumed per wash | Minutes |
| 6 | Time consumed for drying | Minutes |
| 7 | Electricity consumption | Ampere |
| 8 | Gross weight | Kilograms |
| 9 | Operation | Semi-automatic |

### Competitive Benchmarking:

| Metric # | Metric | Units | Competitive Products | | |
|---|---|---|---|---|---|
| | | | Product 1 (I BELL) | Product 2 (EUFY by Anker) | Product 3 (Ecovacsdeebot 500) |
| 1. | type of floor | type | Hard and soft | Carpet | Wood |
| 2. | Type of moping | wet/dry | wet | wet | dry |
| 3. | Type of control | type | App | voice/remote | app/voice |
| 4. | power mode | type | battery | battery | battery |
| 5. | operator needed for process | yes/no | yes | yes | yes |
| 6. | drying | type | N/A | manual | N/A |
| 7. | dimension | cm | 436 X 368 X 11.8 | 32.5 X 32.5 X 7.2 | 33.2 X 33 X. 7.9 |
| 8. | Cleaning path width | cm | 35.8 | 32.5 | 33.2 |

**Phase 4**

## 4.1 Concept Generation

### 4.1 Defining Functions

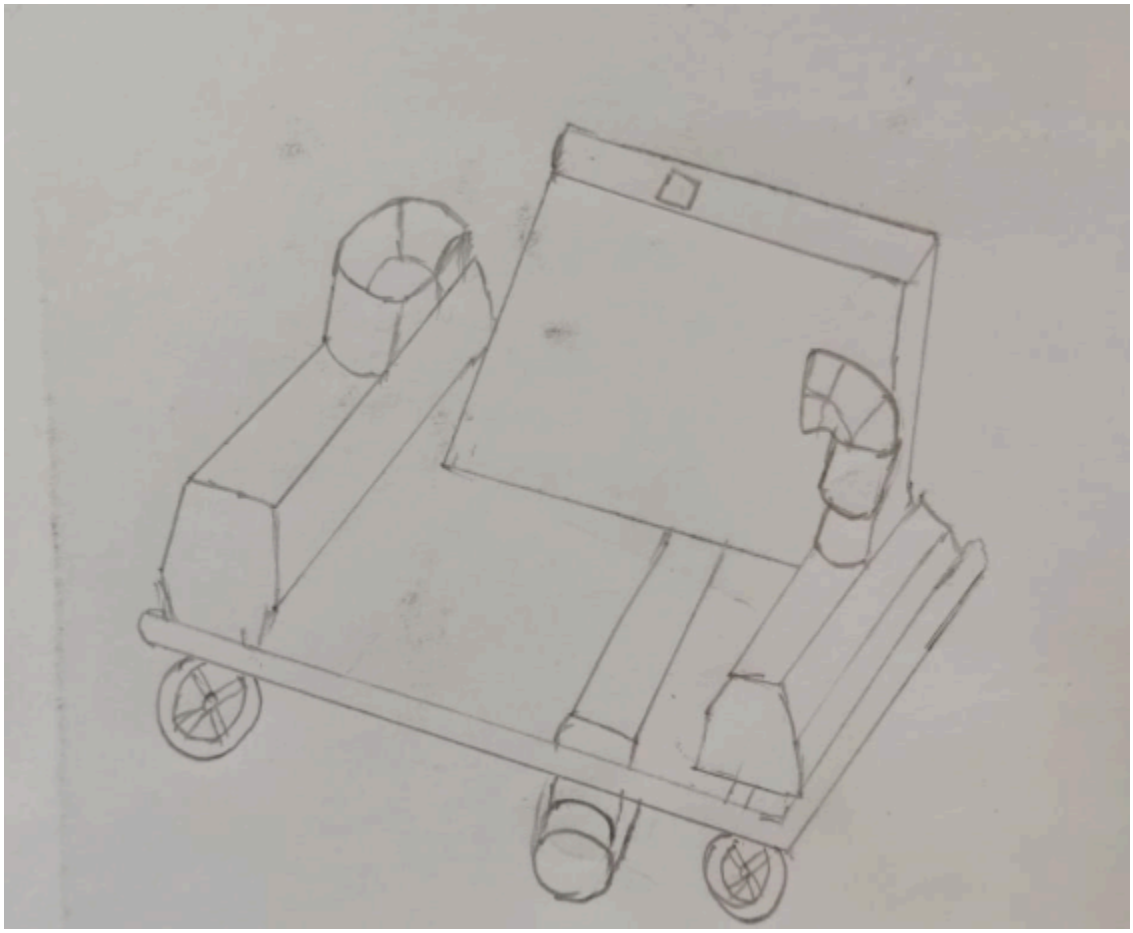
| Si. | Functions | Sub Functions (optional) |
|---|---|---|
| 1 | **Wet cleaning of the floor** | **Stain removing** |
| 2 | **Water resistance of component** | |
| 3 | **Optimum brush speed** | **Proper cleaning of all parts of the floor** |
| 4 | **Modes of cleaning** | |
| 5 | **Spraying disinfectant** | |
| 6 | **Control of water usage & pressure** | **Effective cleaning** |
| 7 | **Notify once its done** | **Notification of every step** |

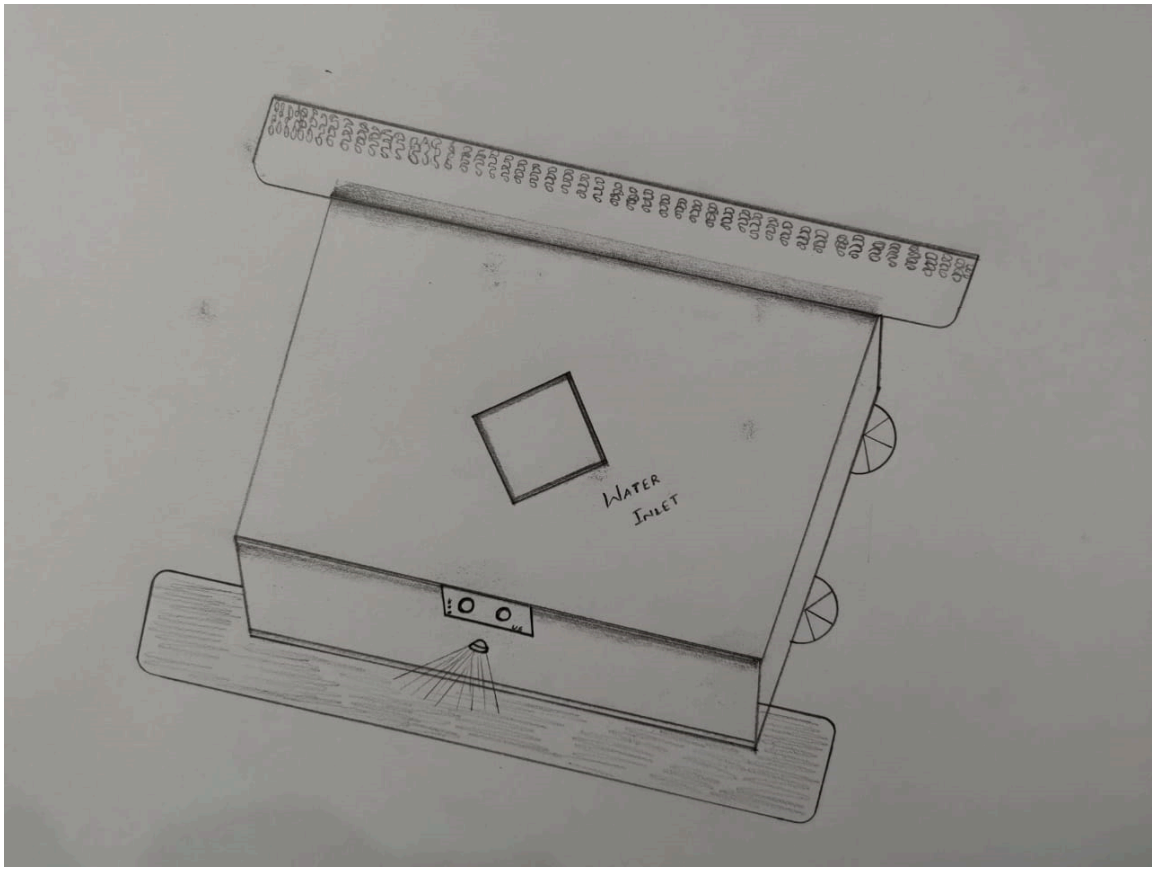
### 4.2 Morphological Chart

| Functions ▼ / Means ► | **Means 1** | **Means 2** | **Means 3** | **Means 4** | **Means 5** |
|---|---|---|---|---|---|
| **Motion of machine** | Straight | Zigzag | Circular | Rotational | |
| **Movement** | Programme | Sensors | Bluetooth controlled | Wheels | |
| **Motion of brushes** | Rotation | Reciprocating motion | Vibration | Zigzag | |
| **Water dispenser** | Inbuilt control | External supply | Sprinkler | Jet spray | |
| **Indication of process** | Transparent | Camera | LED indication | User application | |
| **Disinfectant dispenser** | Container | Sprinkler | Jet spray | Pre-supply of disinfectant | |

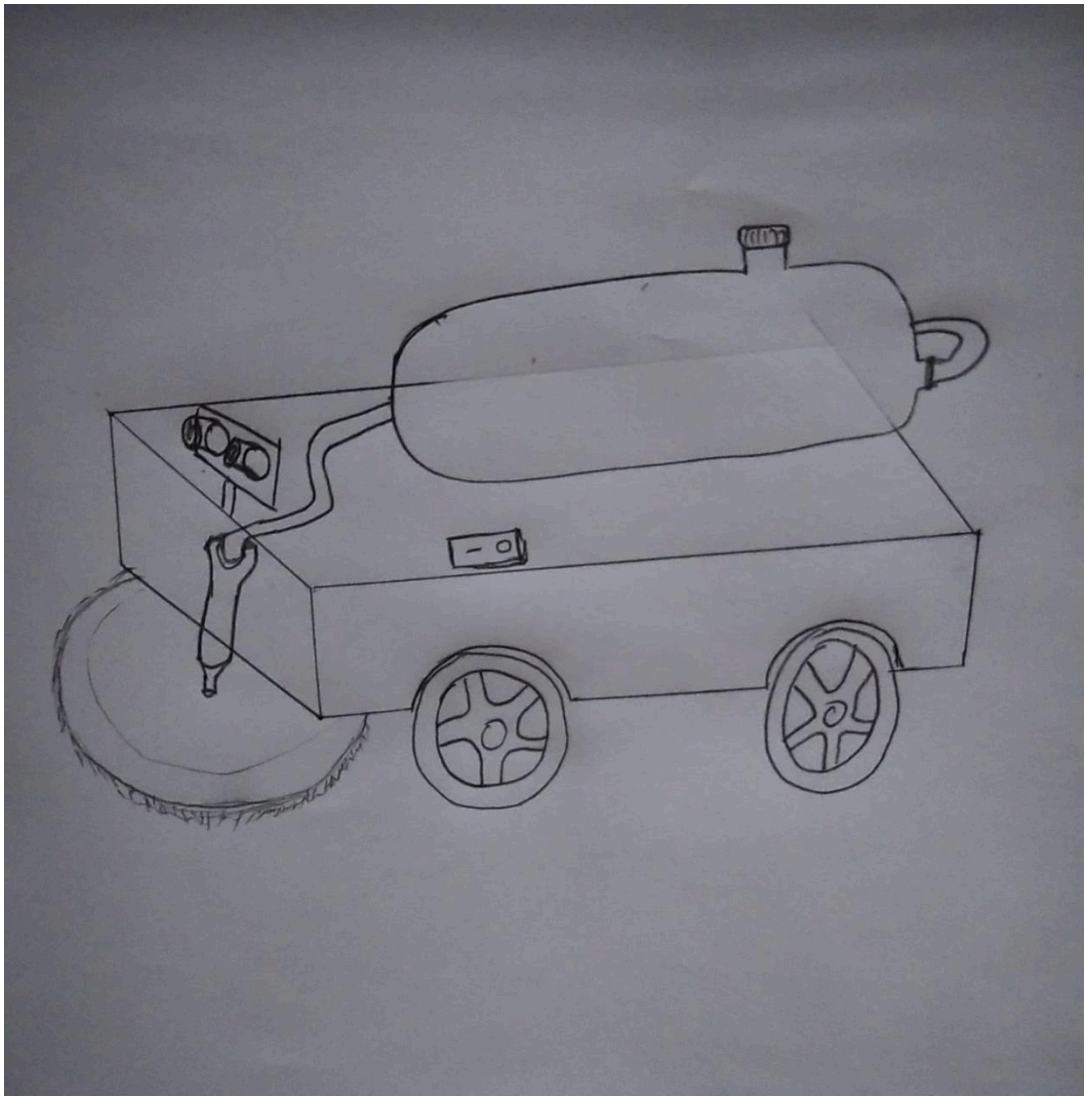
### 4.3 Generating design alternatives

**Sketch of generated design concepts/ alternatives:**

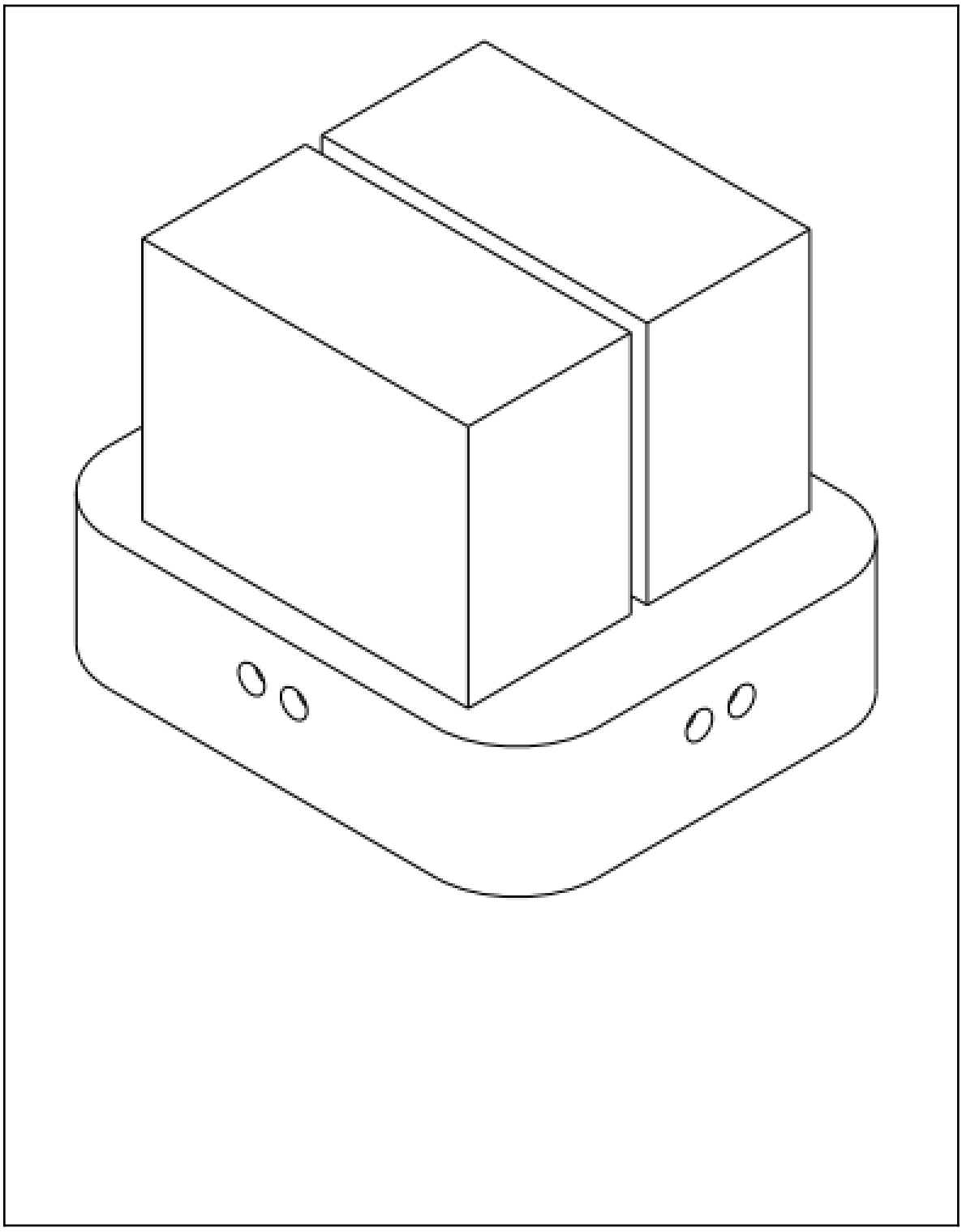
| **Design Alternative 1** |
| --- |
|  |
| **Design Alternative 2** |




**Design Alternative 3**



**Design Alternative 4**

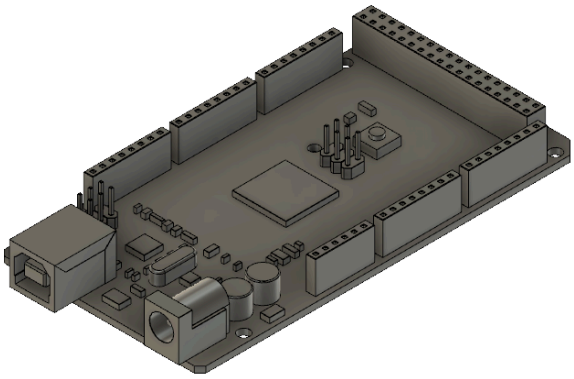
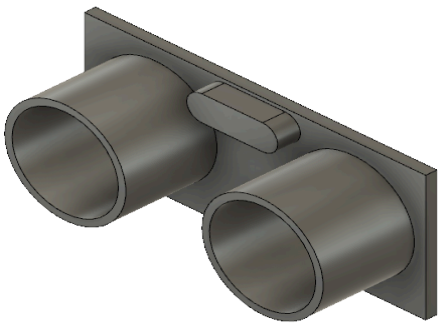


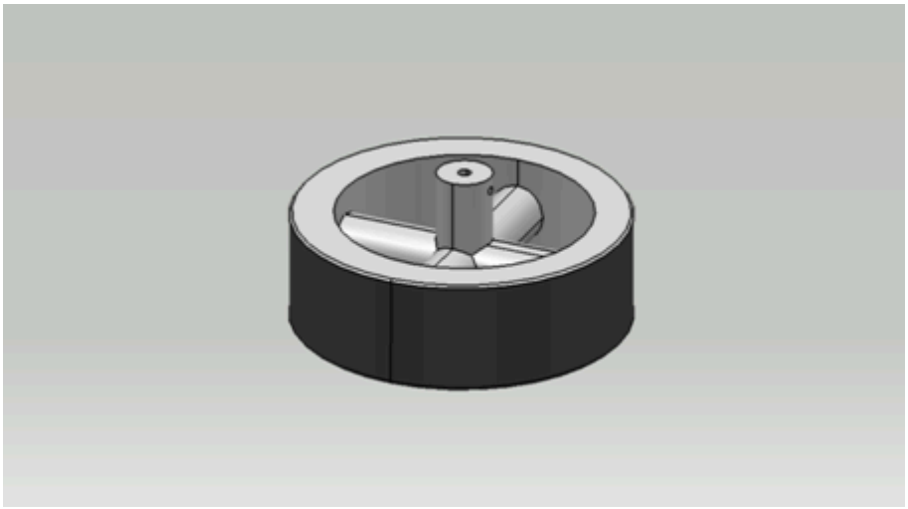
**4.4 Selecting Design Alternative (Using Pugh Chart)**

| Requirements | Weight | Design1 | Design2 | Design3 | Design4 |
|---|---|---|---|---|---|
| Safety | 10 | + | + | + | + |
| Portability | 4 | + | - | - | + |
| Accuracy | 8 | - | - | + | + |
| Efficiency | 7 | + | + | - | + |
| Cost efficient | 8 | - | - | + | - |
| Durability | 7 | + | - | + | + |
| Simple user interface | 8 | - | + | - | + |
| Power | 4 | + | - | - | - |
| **Pluses** | | 5 | 3 | 4 | 6 |
| **Minuses** | | 3 | 5 | 4 | 2 |
| **Overall Total** | | 2 | -2 | 0 | 4 |
| **Weighted Total** | | 27 | -9 | 7 | 35 |
| **Yes / No** | | No | No | No | Yes |

**Selected Design Alternative: DESIGN 4**

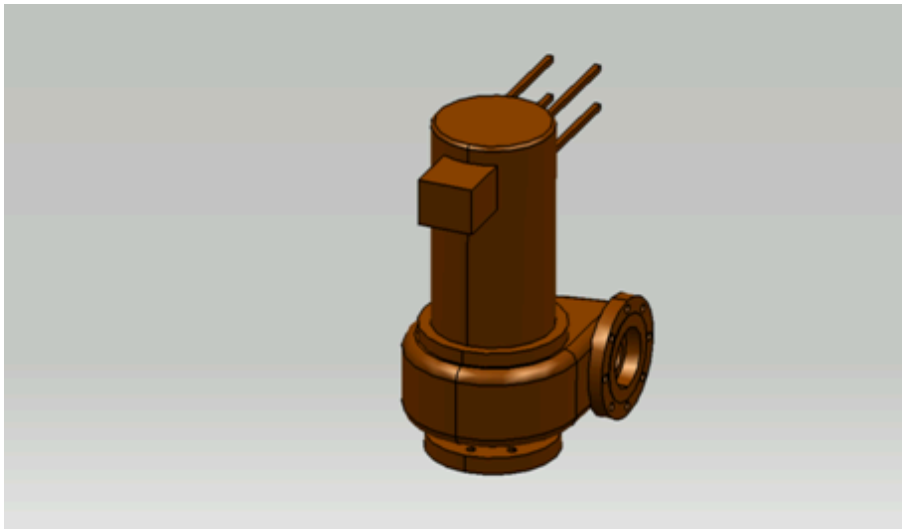
**5.1 3D Model**

| ARDUINO |
| --- |
|  |
| **ULTRASONIC SENSOR** |
|  |
| **WHEEL** |

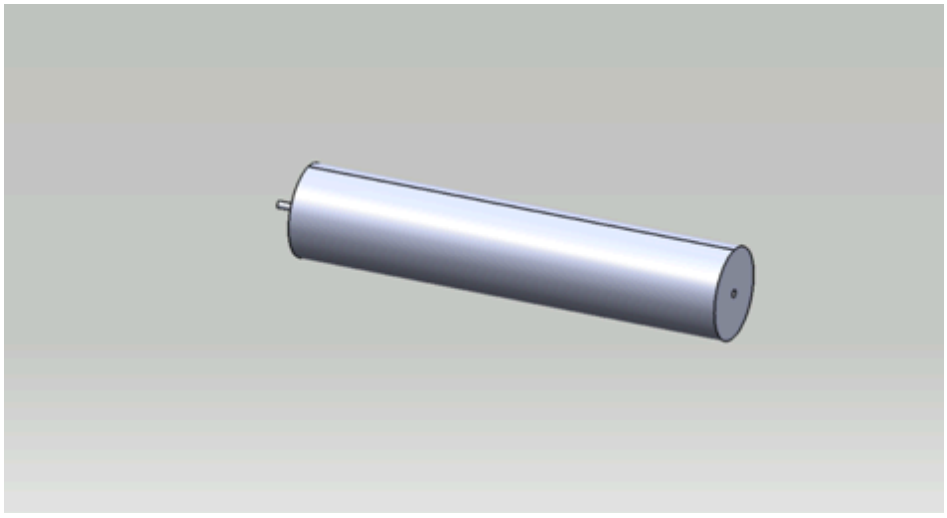


**SPRINKLER PIPE**

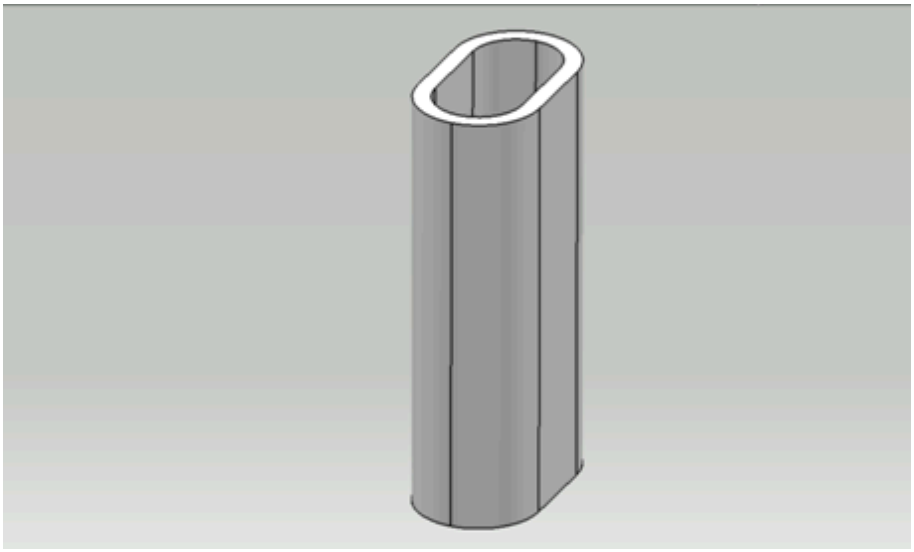
**SPRINKLER PUMP**



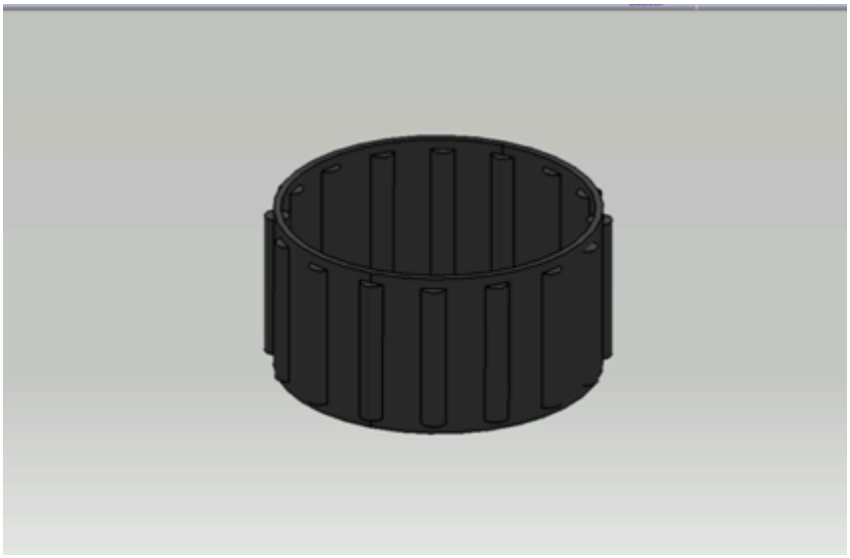
**SPINDLE**



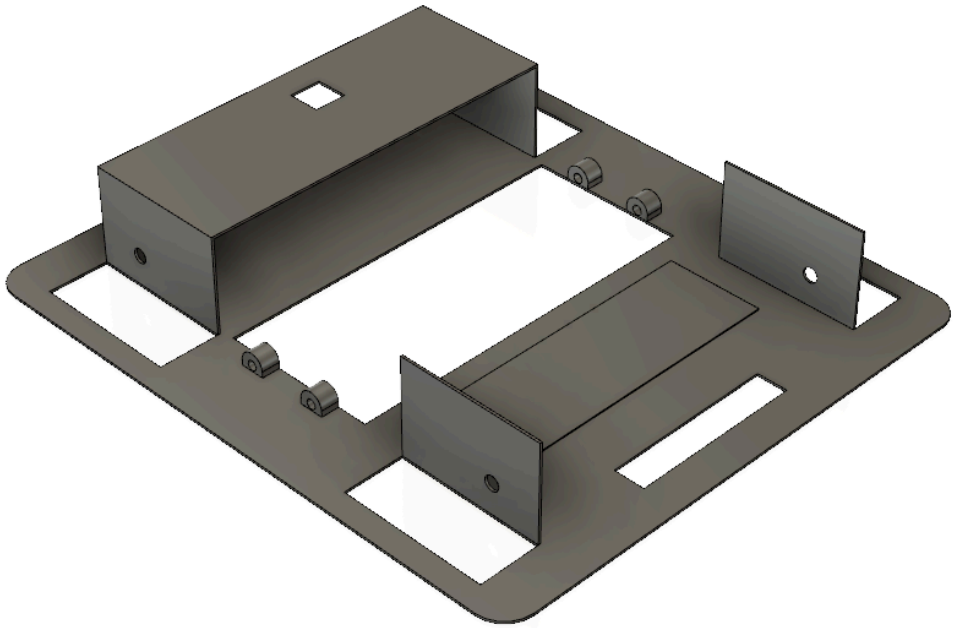
## SPONGE



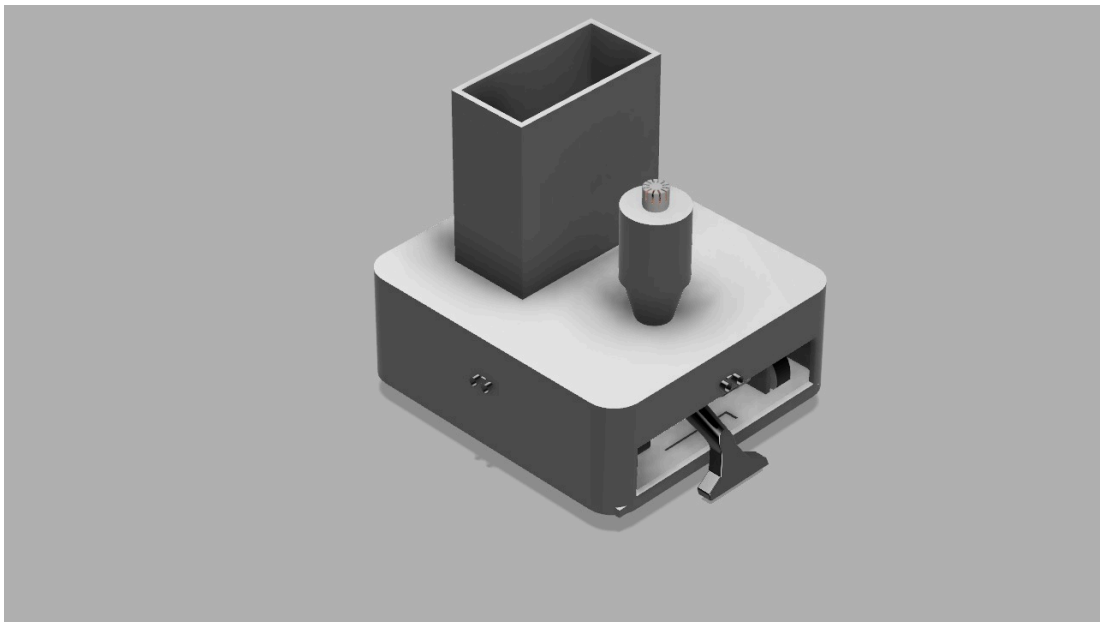
## BALL BEARING HUB

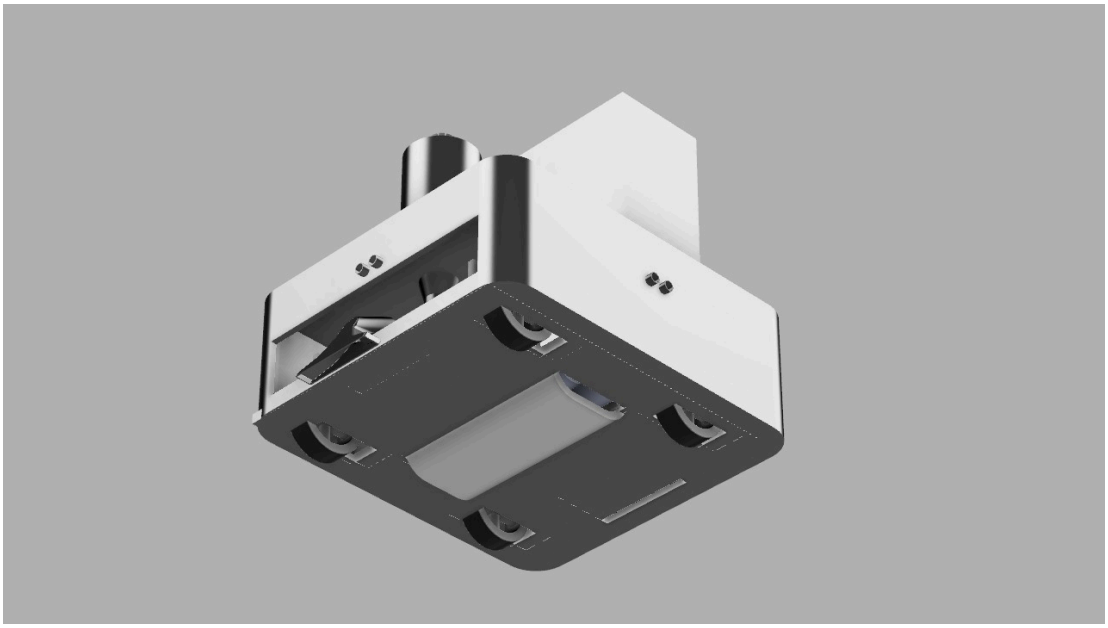


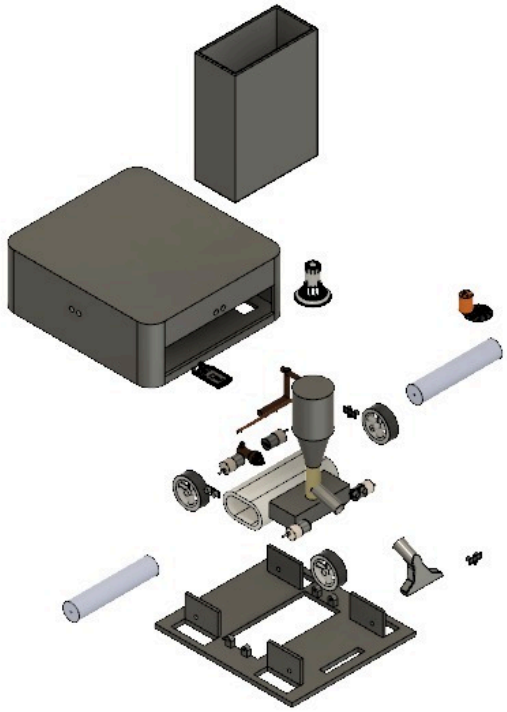
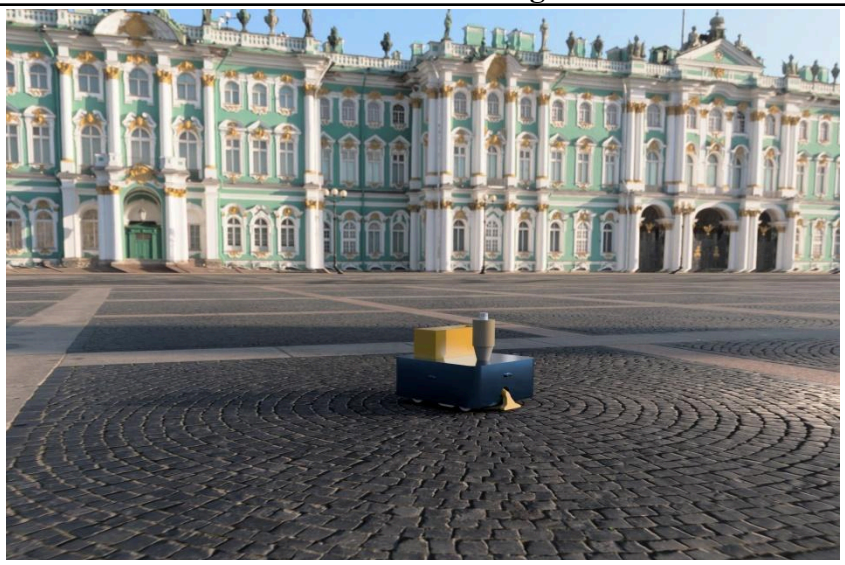
## CHASSIS



**5.2** Assembly models

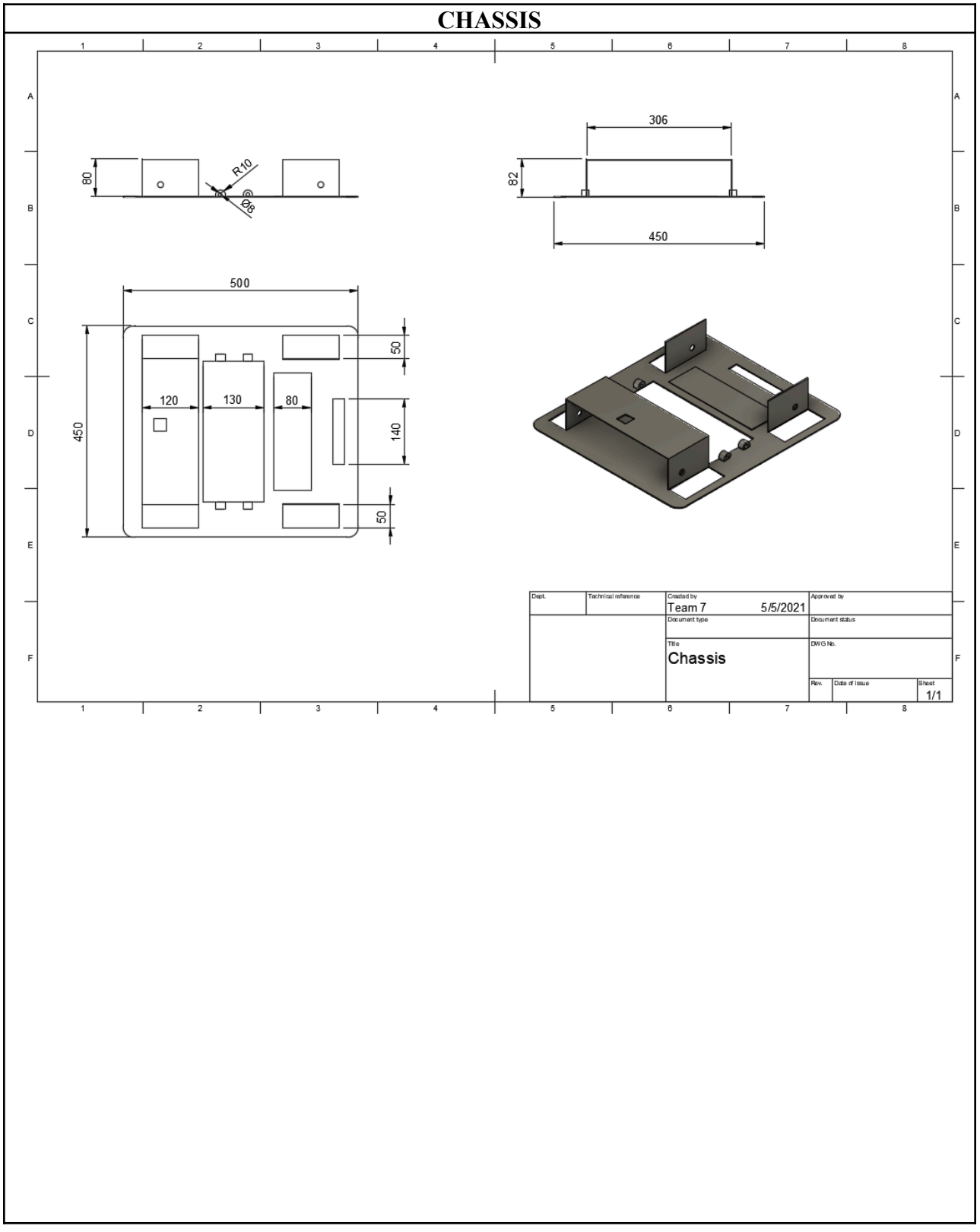
| **Assembly Model** |
| --- |
|  |



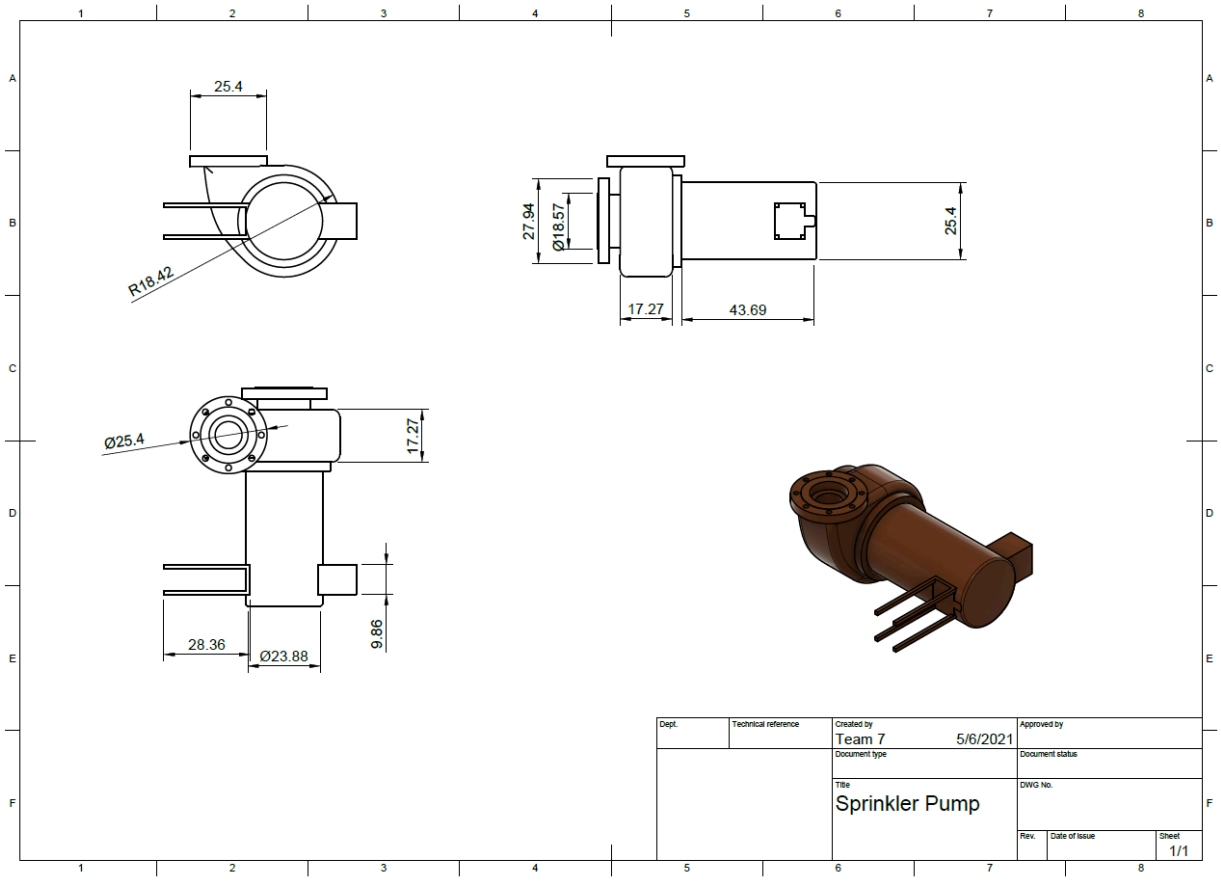
| Exploded View |
| --- |
|  |
| **3D Rendered Image** |
|  |

## 5.3 2D Drawings

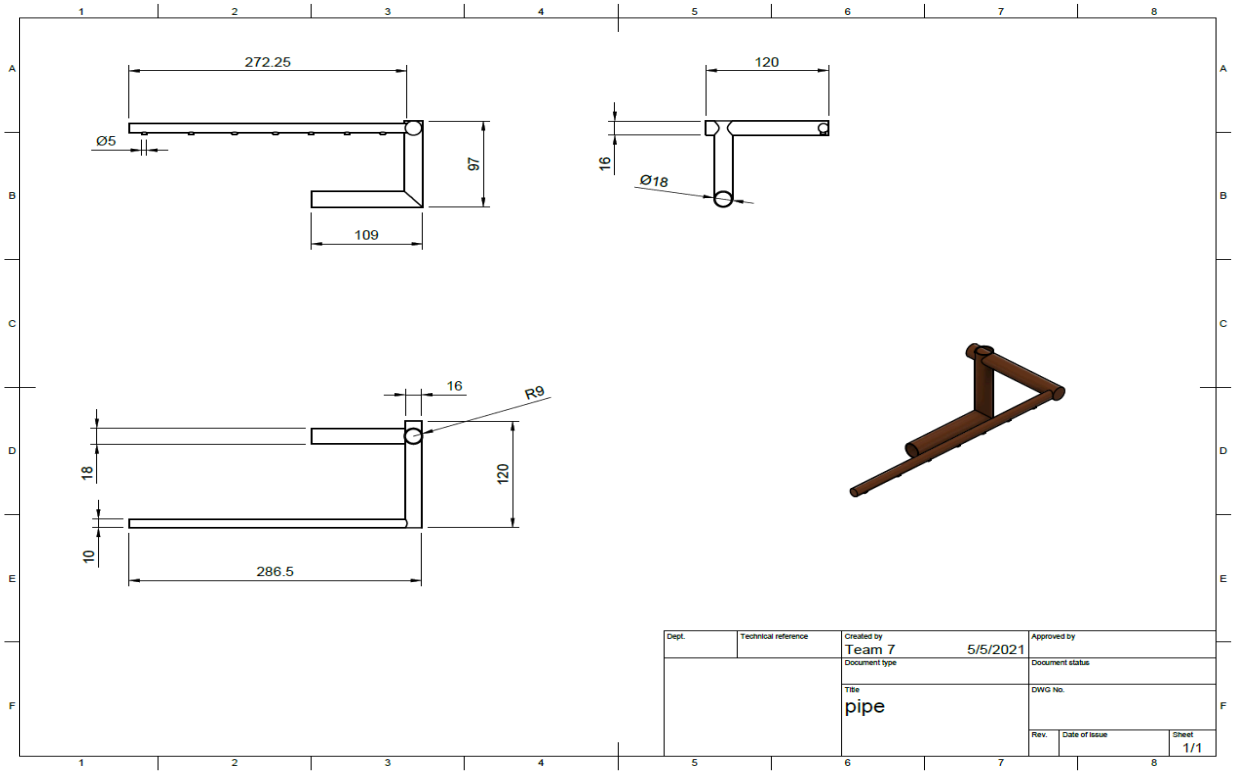
(*Note: all dimensions are in mm)



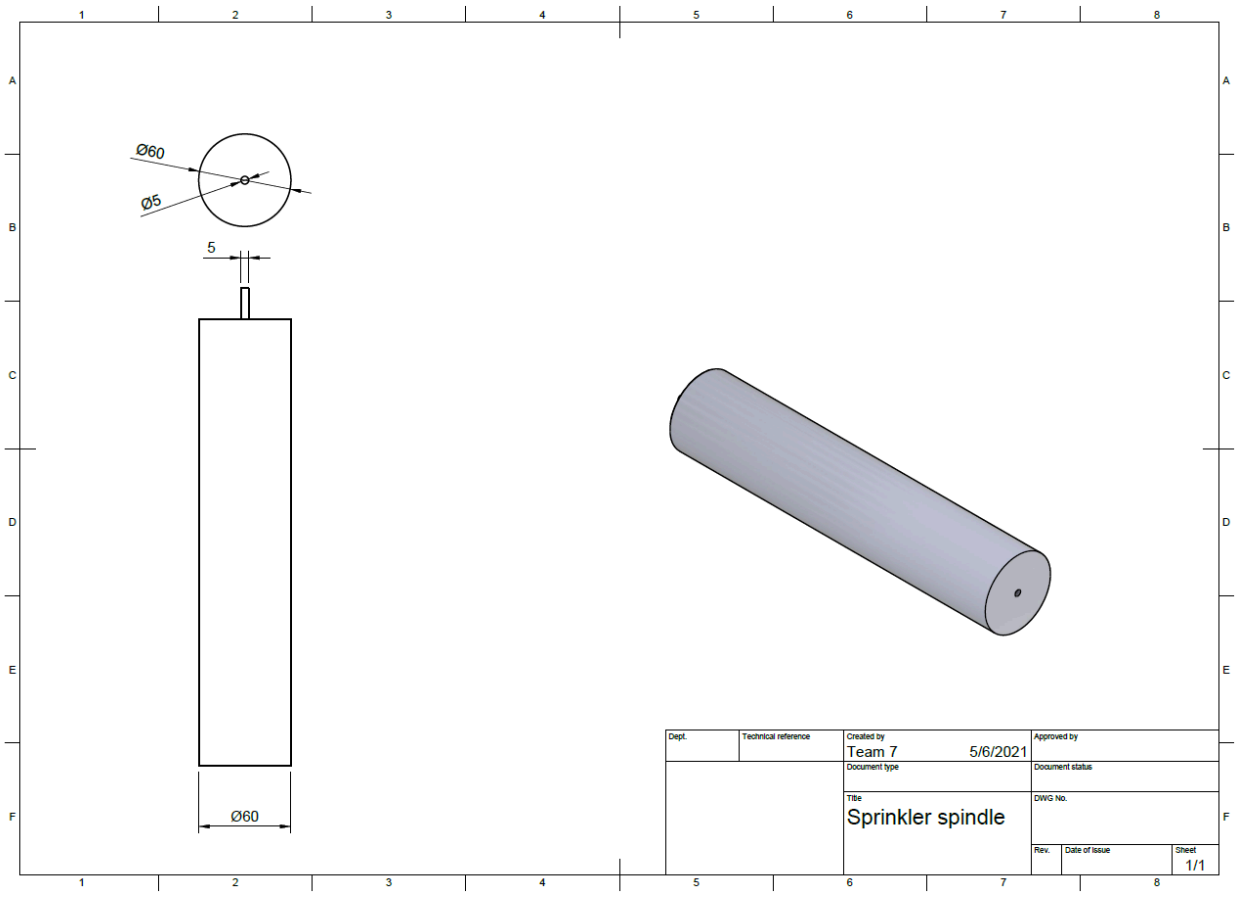
## SPRINKLER PUMP



## SPRINKLER PIPE



## SPINDLE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DWG No.
Rev.
Date of issue
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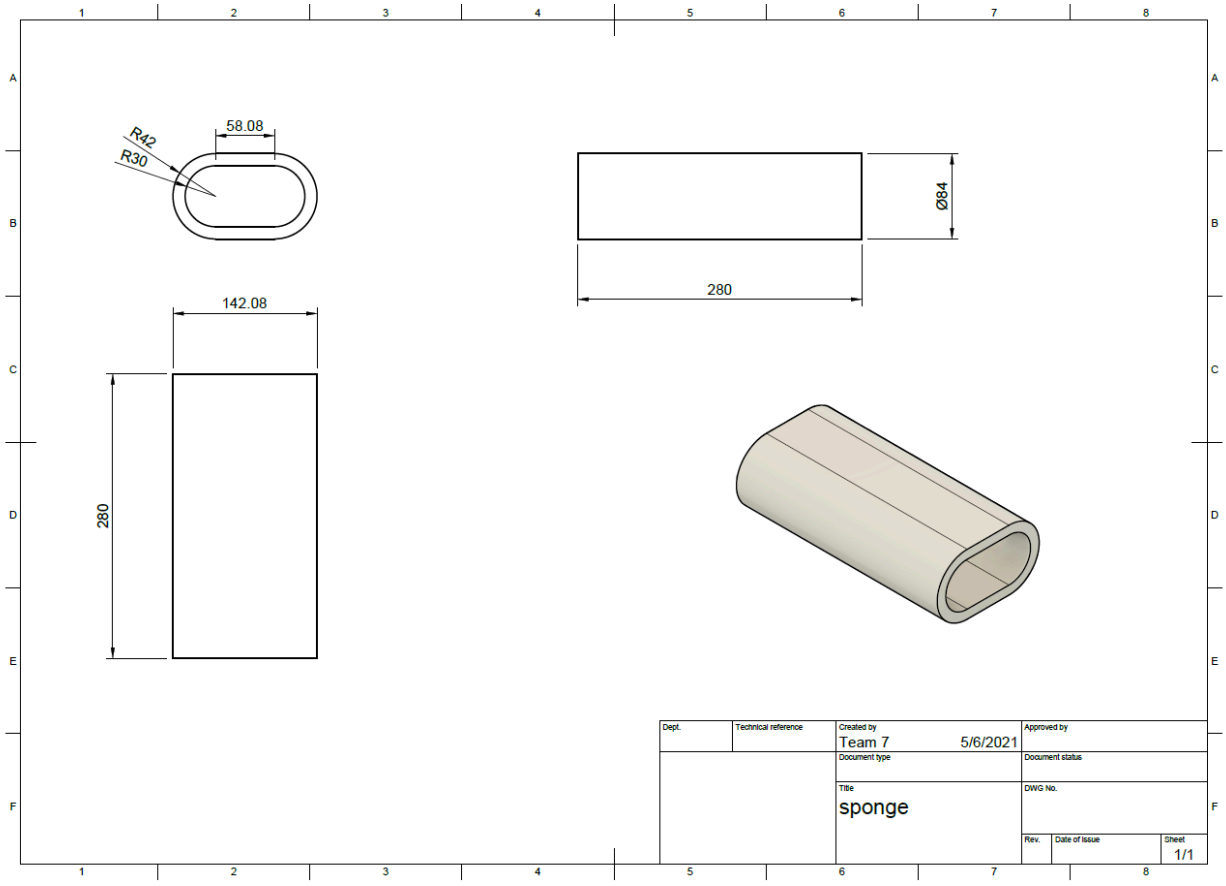
## SPONGE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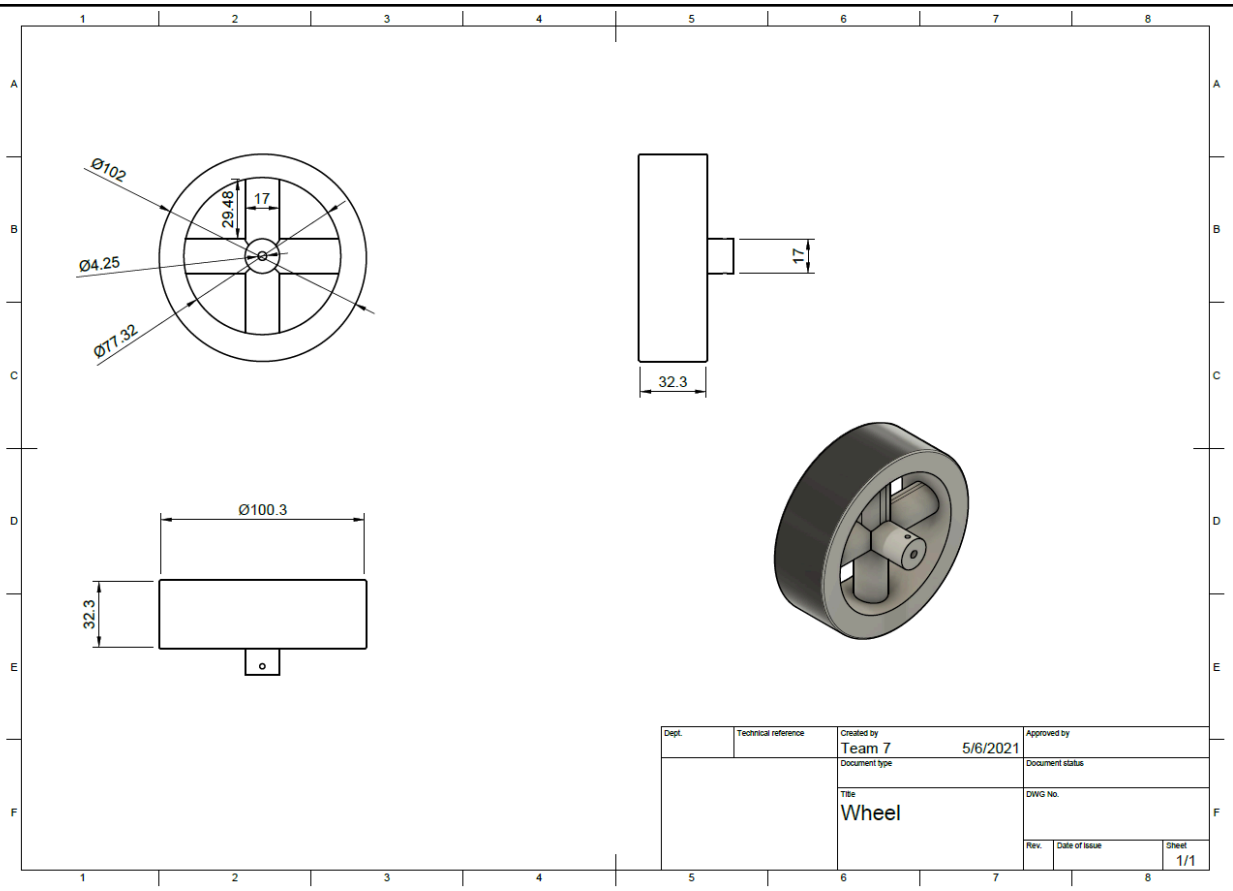
# WHEEL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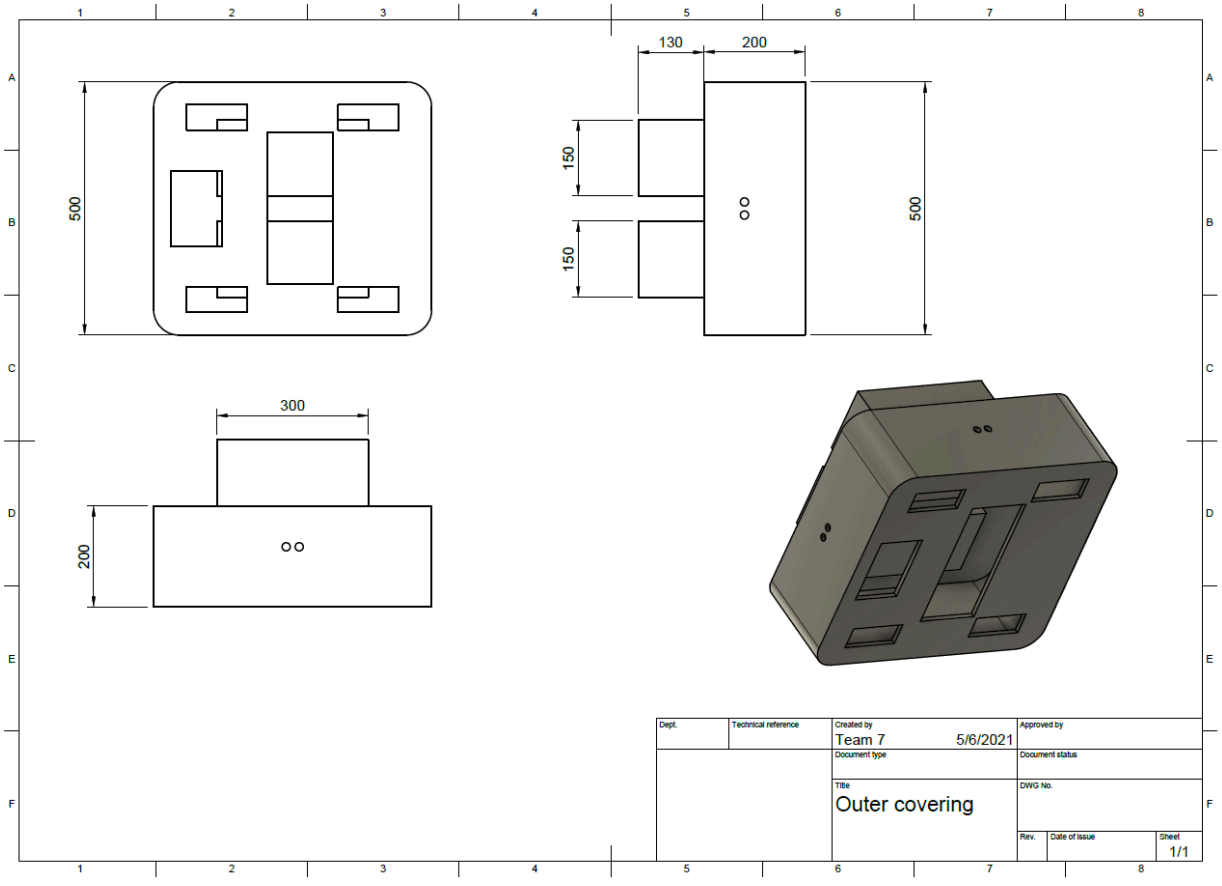
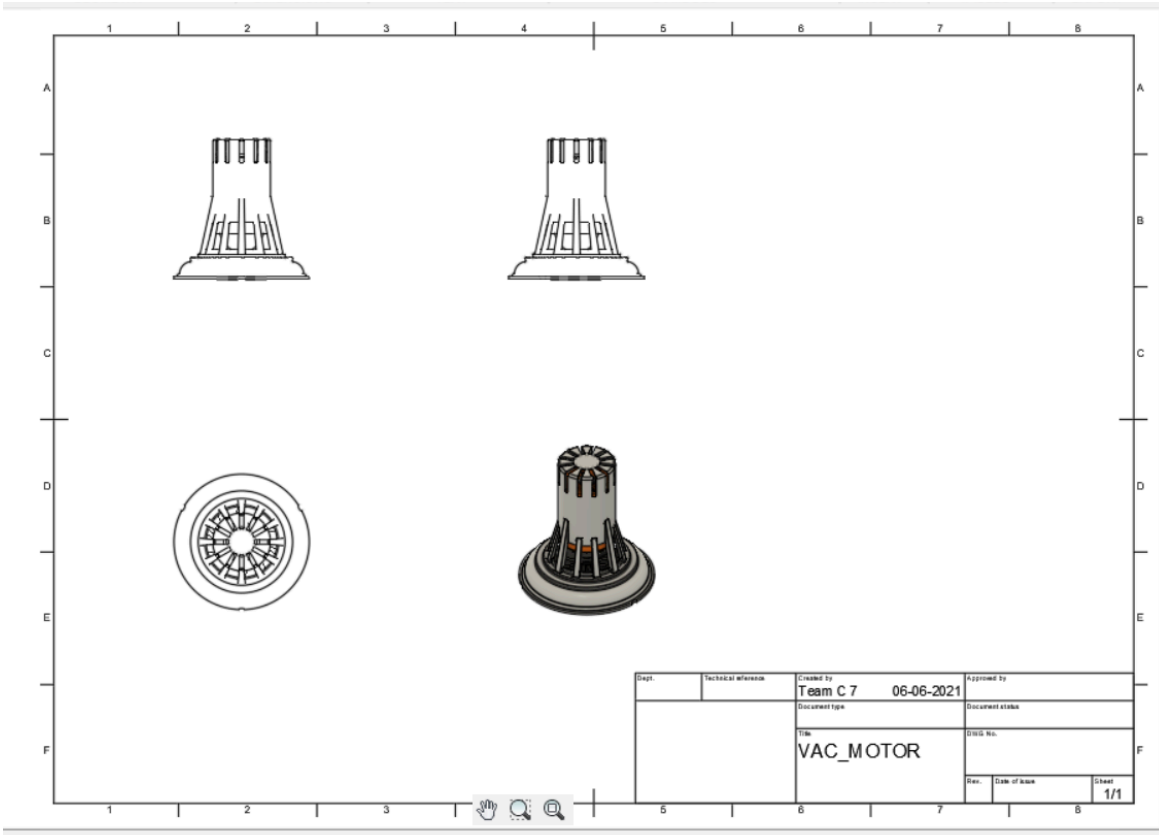
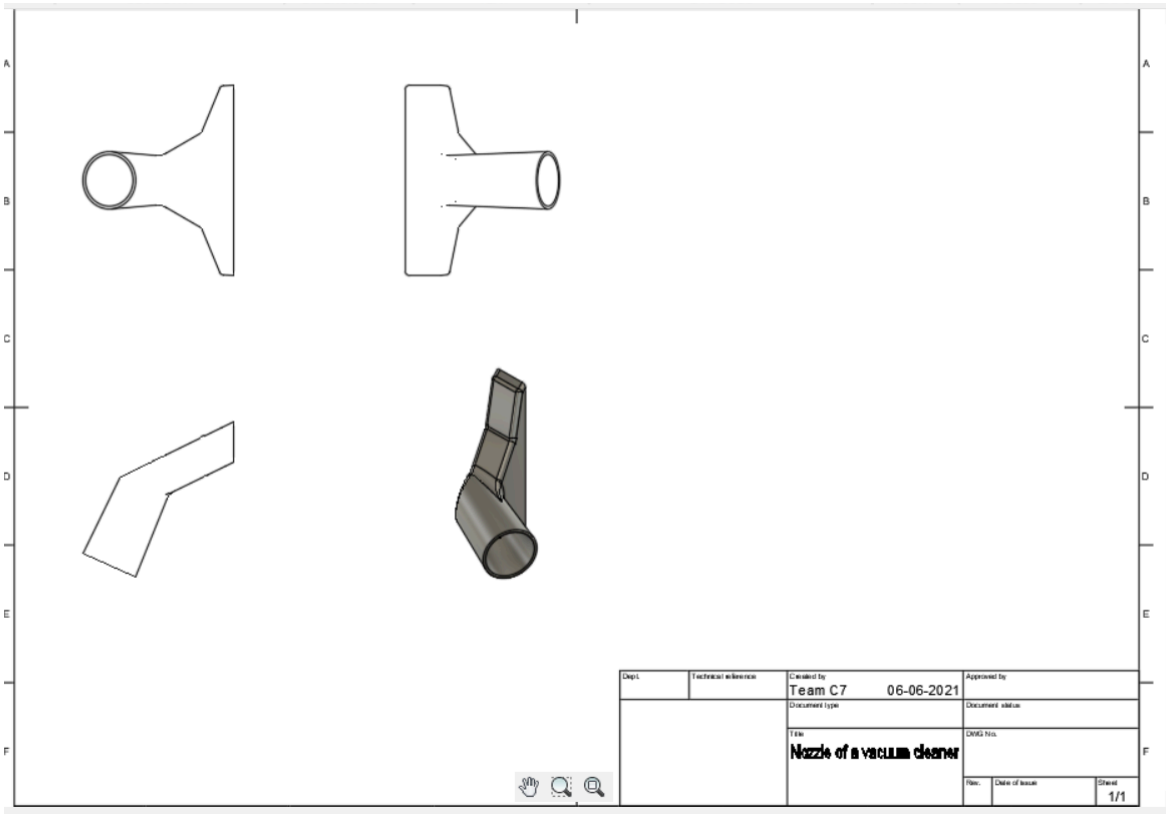
# OUTER CASING



## Vacuum Motor

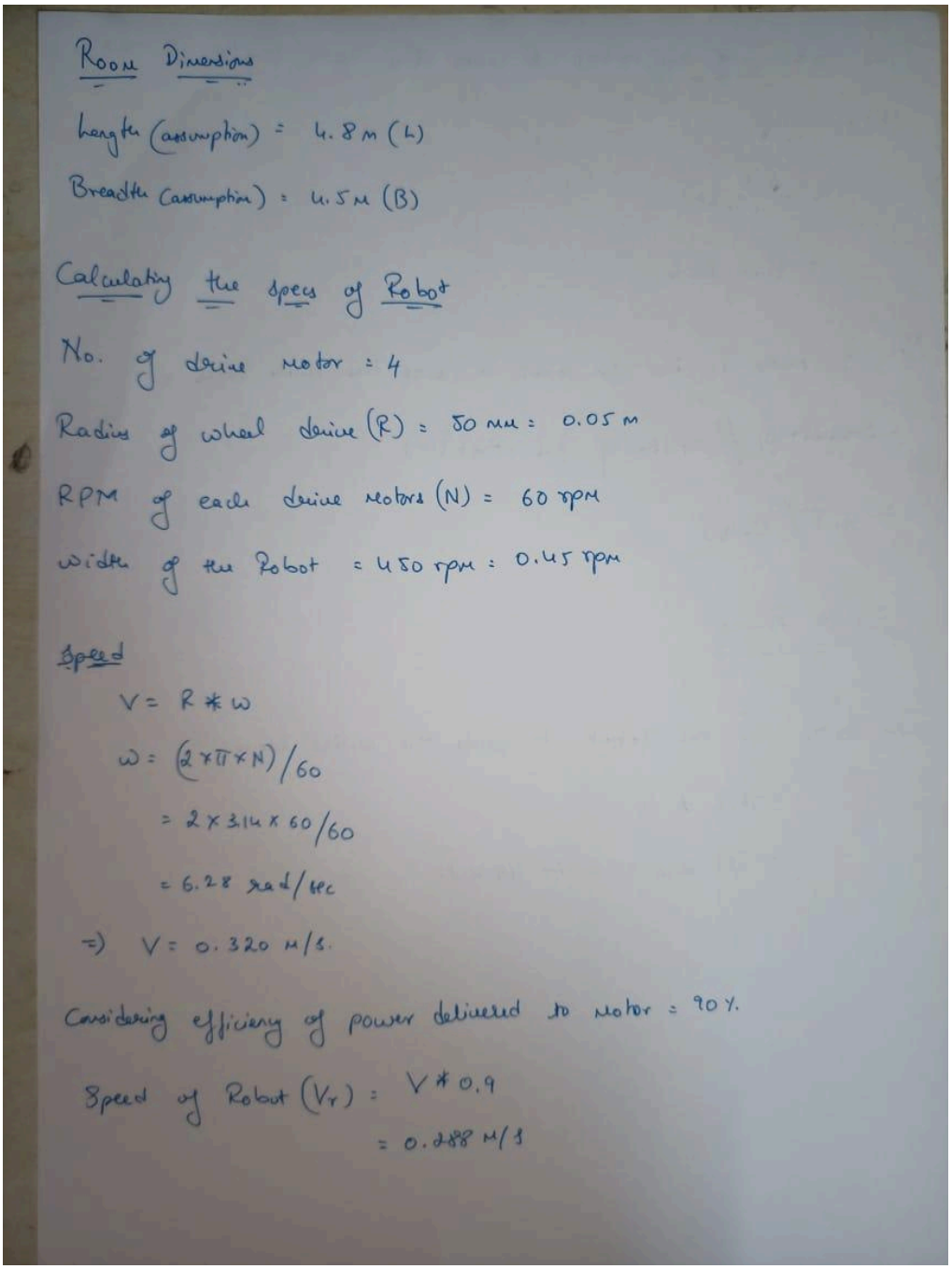


## Nozzle



## 5.4 Design Calculations

**Design Calculations**



Room Dimensions

Length (assumption) = 4.8 m (L)

Breadth (assumption) = 4.5 m (B)

Calculating the specs of Robot

No. of drive motor = 4

Radius of wheel drive (R) = 50 mm = 0.05 m

RPM of each drive motors (N) = 60 rpm

width of the Robot = 450 rpm = 0.45 rpm

Speed

$V = R * \omega$

$\omega = (2 \times \pi \times N)/60$

$= 2 \times 3.14 \times 60/60$

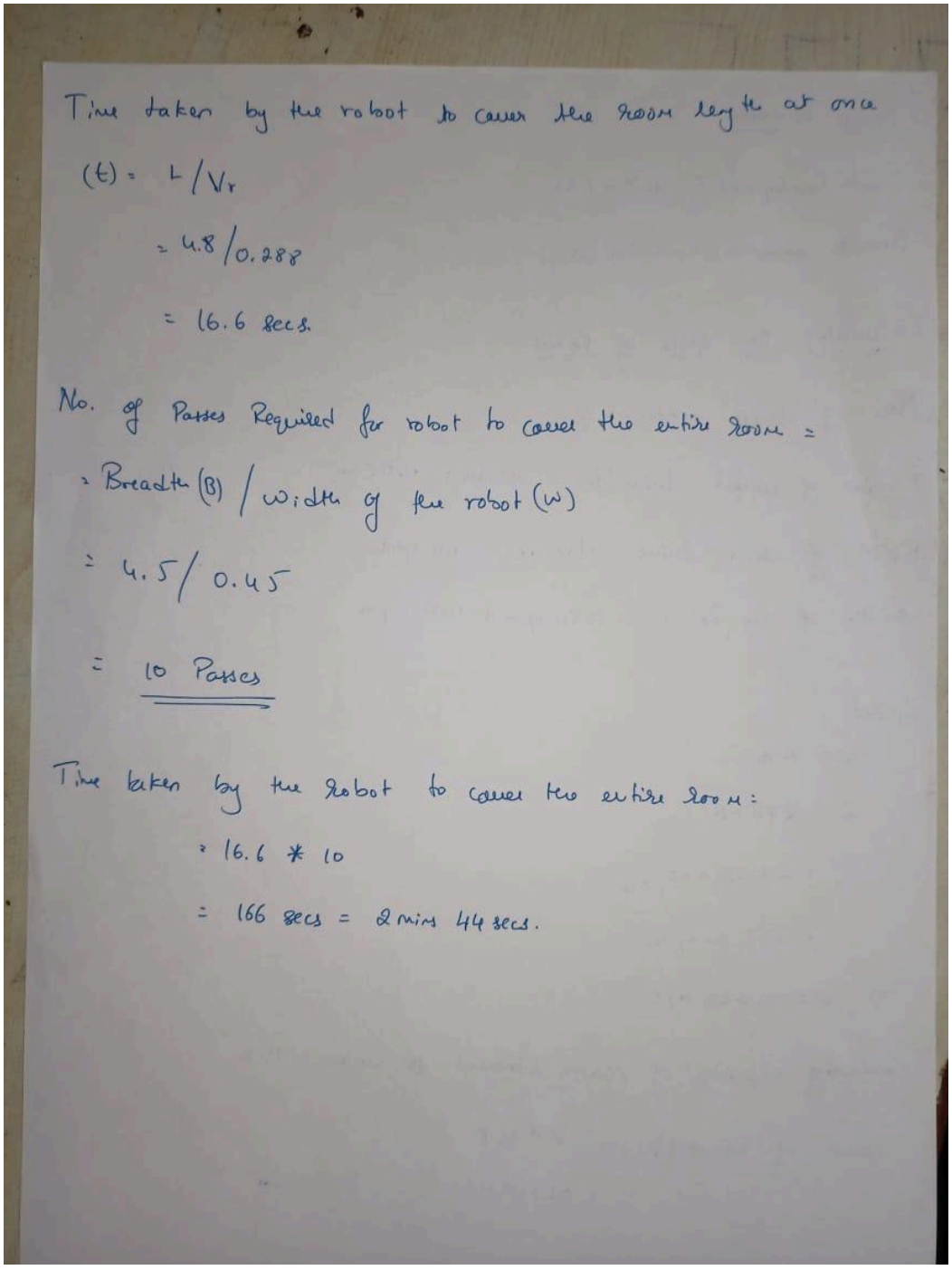
$= 6.28$ rad/sec

$\Rightarrow V = 0.320$ m/s.

Considering efficiency of power delivered to motor = 90%.

Speed of Robot ($V_r$) = $V * 0.9$

$= 0.288$ m/s



Time taken by the robot to cover the room length at once

$(t) = L / V_r$

$= 4.8 / 0.288$

$= 16.6$ secs.

No. of Passes Required for robot to cover the entire room =

= Breadth (B) / width of the robot (w)

$= 4.5 / 0.45$

= 10 Passes

Time taken by the robot to cover the entire room:

$= 16.6 * 10$

$= 166$ secs $= 2$ mins 44 secs.

## 5.4 Bought out and Manufactured Parts

| Bought out parts | Manufactured Parts |
|---|---|
| • Ultrasonic Sensor<br>• Arudino<br>• Wheels<br>• Dc motor<br>• Sponge<br>• Bluetooth module<br>• Battery<br>• Ball bearing hub | • Chassis<br>• Vaccum suction inlet with storage<br>• Sprinkler pipe<br>• spindle |

### 6.2 Bill of Materials

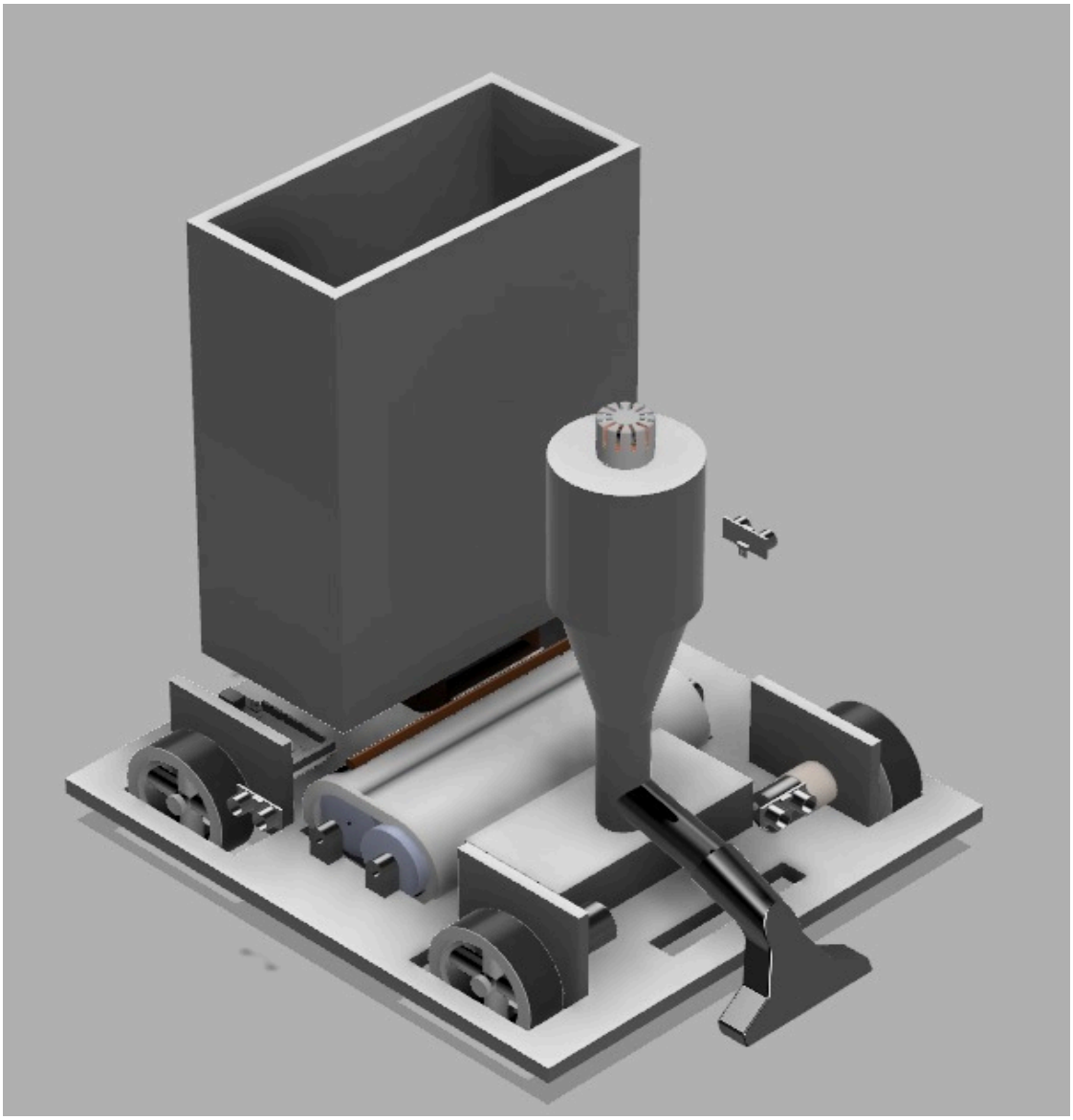
| Si No | Part Number | Part Name | Quantity | Material Specification |
|---|---|---|---|---|
| 1 | | Ultrasonic Sensor | 4 | ----- |
| 2 | | Arduino | 1 | ----- |
| 3 | | Chassis | 1 | Mild steel |
| 4 | | Wheels | 4 | OEM |
| 5 | | DC Motor (60rpm) | 4 | ----- |
| 6 | | DC Motor (600rpm) | 1 | ----- |
| 7 | | Outer casing with water & dust storage | 1 | Aluminum |
| 8 | | Vacuum system | 1 | ----- |
| 9 | | Sponge | 1 | OEM |
| 10 | | Bluetooth module | 1 | ----- |
| 11 | | Ball bearing hub | 1 | ----- |

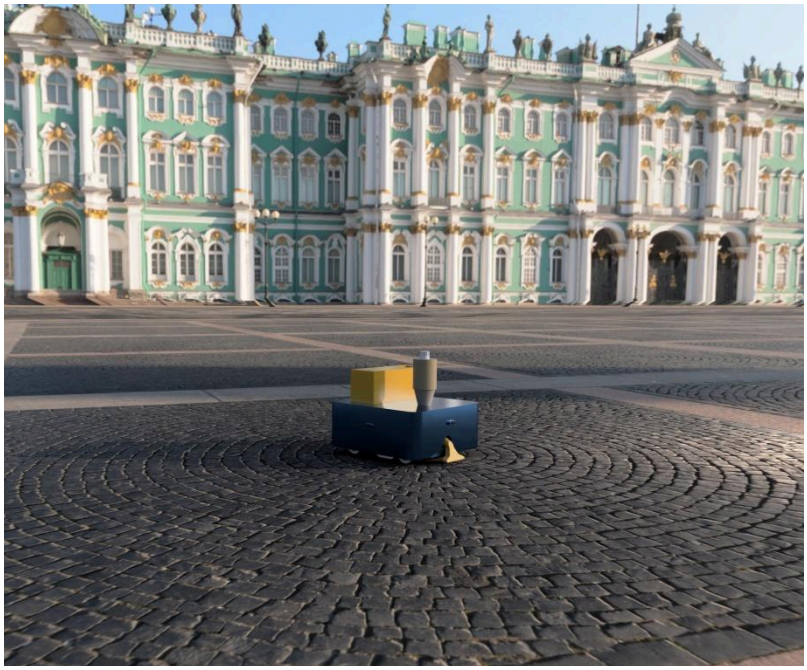
| | | | | |
|---|---|---|---|---|
| 12 | | Motor driver | 3 | ----- |
| 13 | | Battery | 1 | ----- |
| 14 | | Sprinkler pump | 1 | ----- |
| 15 | | Sprinkler pipe | 1 | PVC |
| 16 | | Spindle | 1 | Stainless steel |

### 6.3 Joining techniques/ methods:

| # | Joining Method | Material to be joined | Resources required and specification |
|---|---|---|---|
| 1 | Welding | Sheet Metal | 40/80 2 sheet MS |
| 3 | Adhesives | Acrylic, Metal | M-SEAL |

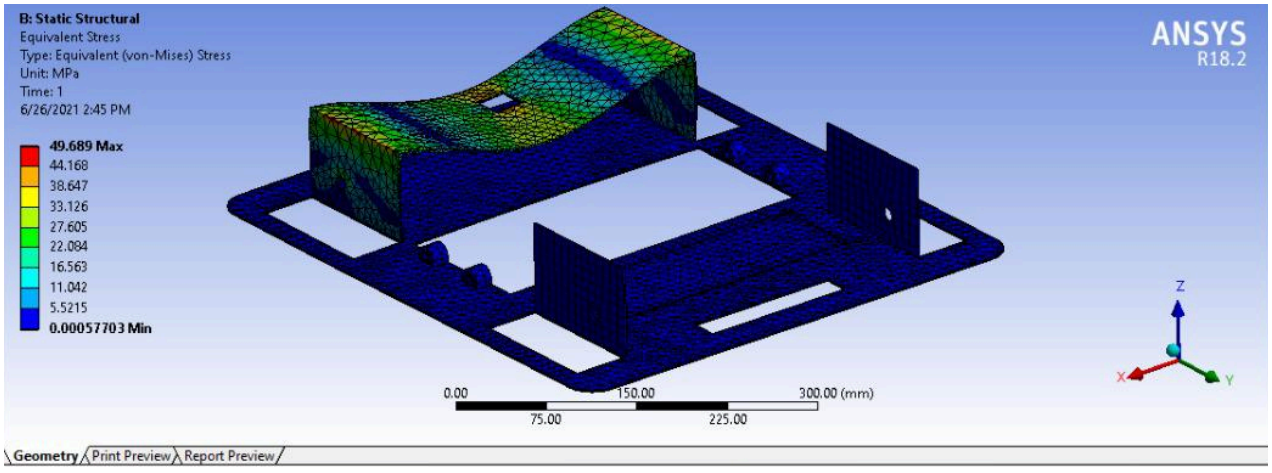
**3D model:**



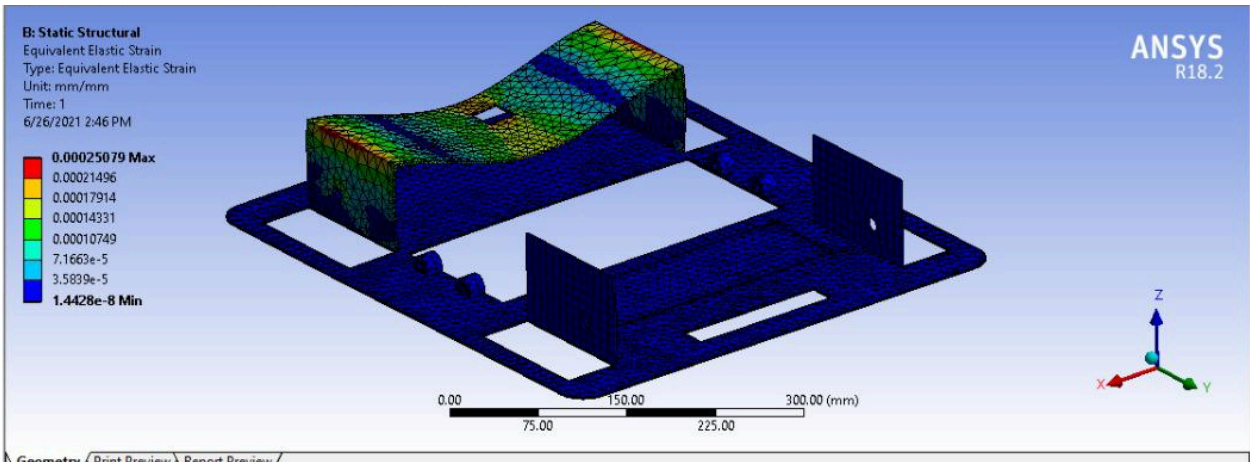


**FEM Analysis:**

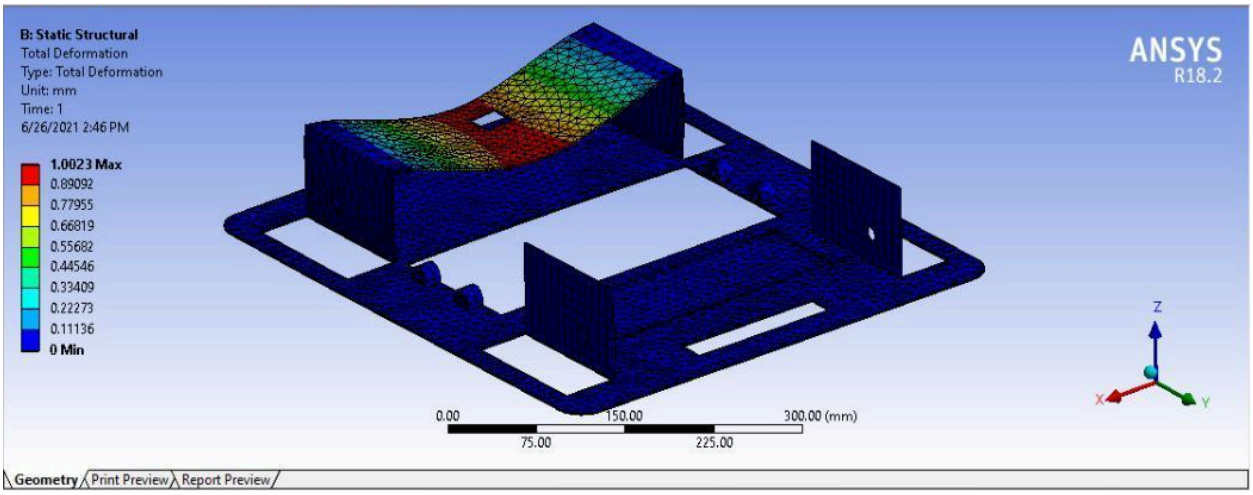
1) **STATIC STRUCTURAL STRESS ANALYSIS**



## 2) STATIC STRUCTURAL STRAIN ANALYSIS




## 3) STATIC STRUCTURAL TOTAL DEFORMATION




**Analysis details:**

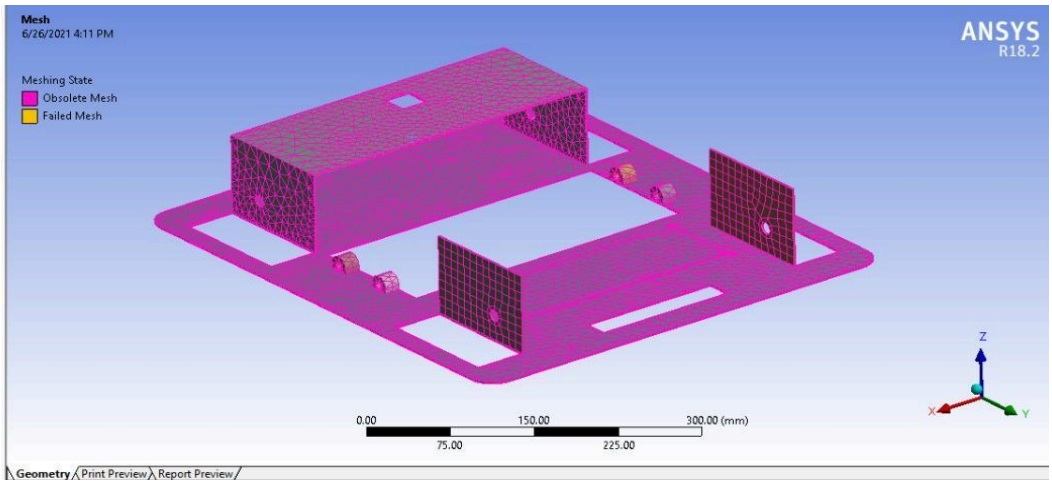
**Material Type : Aluminum Alloy :- Yield Stress = 90 Mpa**

**Mesh Type : Tetrahedron – Fine**

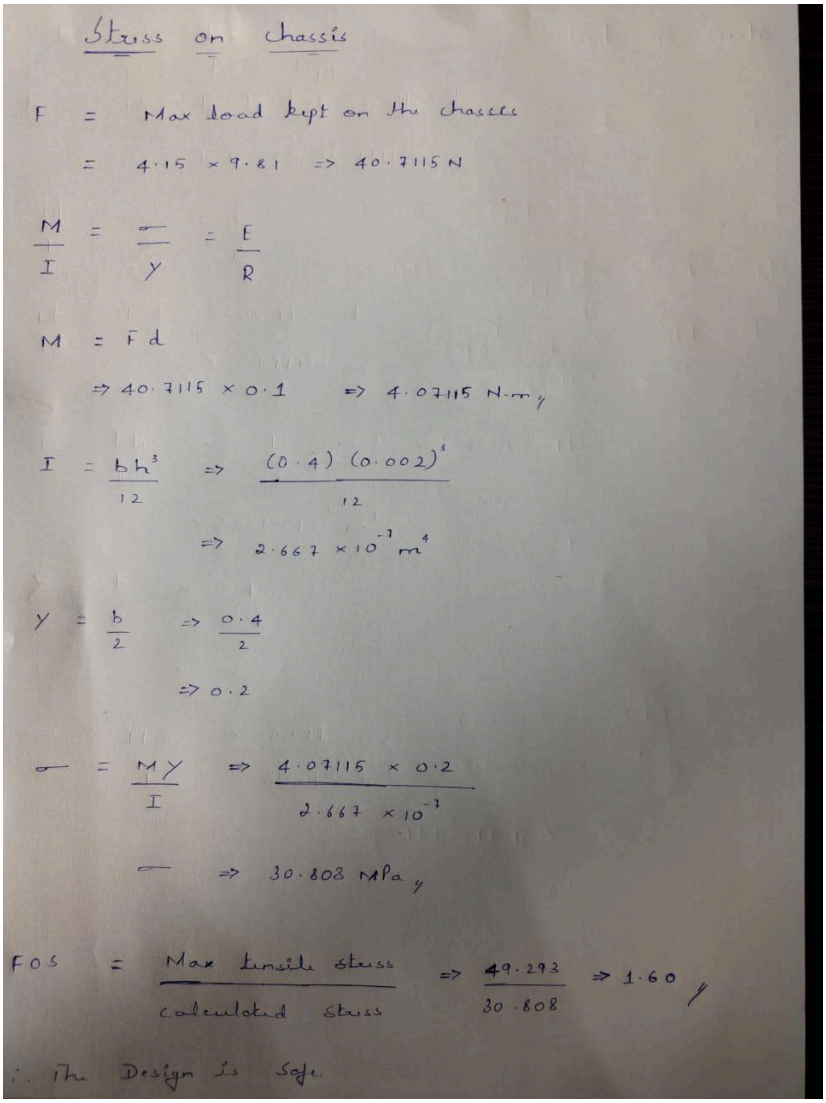
**Boundary Conditions : Water Storage Weight = 2 Kg (Max)**

**Dust Storage Weight = 0.3 Kg (Max)**

**Total Load On Chassis = 4.15 * 9.81 = 40.7115 N**



## RESULT & DISSCUSIONS:



Stress on chassis

F = Max load kept on the chassis

= 4.15 × 9.81 ⇒ 40.7115 N

$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$

M = F d

⇒ 40.7115 × 0.1 ⇒ 4.07115 N-m

$I = \frac{bh^3}{12} \Rightarrow \frac{(0.4)(0.002)^3}{12}$

$\Rightarrow 2.667 \times 10^{-7}\ m^4$

$y = \frac{b}{2} \Rightarrow \frac{0.4}{2}$

⇒ 0.2

$\sigma = \frac{My}{I} \Rightarrow \frac{4.07115 \times 0.2}{2.667 \times 10^{-7}}$

$\sigma \Rightarrow 30.803$ MPa

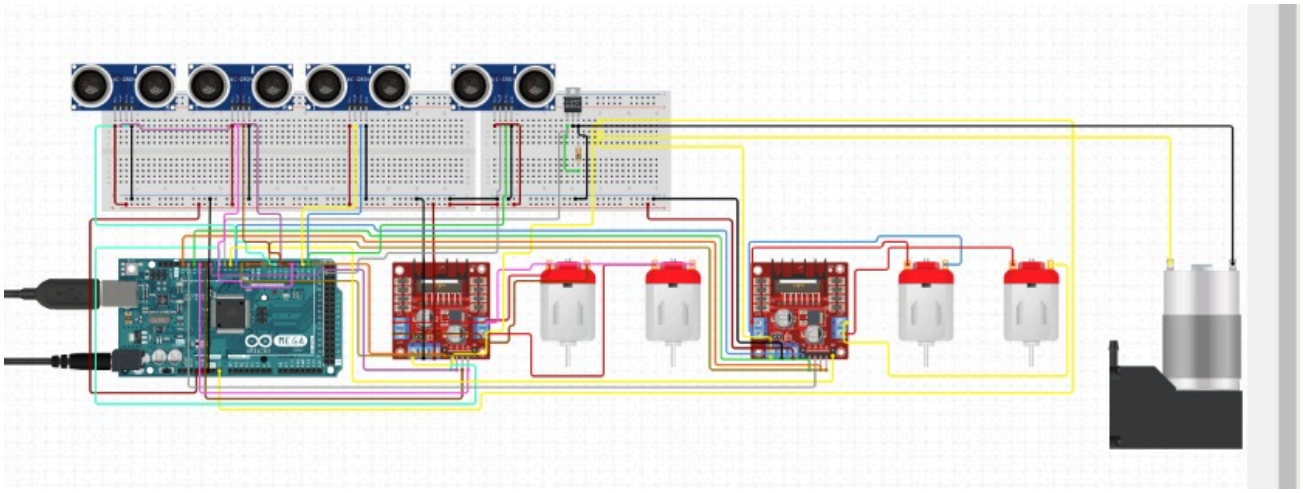
$FOS = \frac{\text{Max tensile stress}}{\text{calculated stress}} \Rightarrow \frac{49.293}{30.808} \Rightarrow 1.60$

∴ The Design is Safe.

**FOS = 1.6**

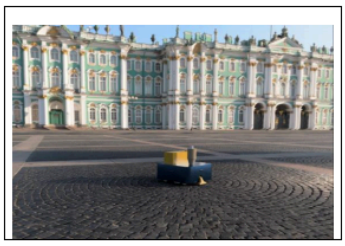
**The Design is Safe.**

## Circuit Diagram:



## Product Catalogue:

### Product in use:



**Operating Instructions:**

- Pour required amount of water in the water storage.
- Turn on/off the switch to start/stop cleaning.
- If the sponge gets dirty/torn, remove the above case and replace the sponge with a good one.
- And also clean the dust storage by doing the same as mentioned above

### Team Members:

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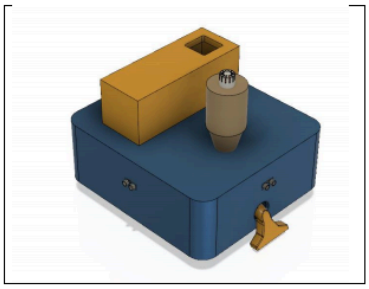
### "SMACBOT"

*"TIRED OF USING A BROOM,*
*USE SMACBOT TO HAVE A CLEAN ROOM"*

**SMART FLOOR MOPPING DEVICE**



School of Mechanical Engineering

*Minor Project Team C7*

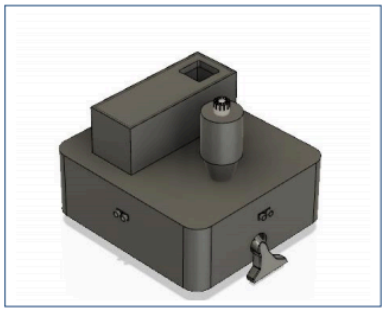
## Introduction:

*The major problem faced by Households/ Malls/Hotels and many buildings these days is cleaning of dirty floors, which requires hard work and is also time consuming, This is a Smart Floor Mopping Robot, which is specifically designed to reduce the workload and time taken to clean.*

## Features:

- Cost effective with respect to existing products
- Does Both Vacuum suction and Mopping
- Semi-automatic
- Rust free
- Auto Obstacle detection and moves accordingly.
- Safe, user friendly operation.

## 3D Model:



## Background/Introduction

*It requires less labor work and there is no requirement of skilled labor to operate. This ergonomically designed machine controlled by an arduino uses less water than the manual cleaning methods.*

## Product Specifications:

- Machine weight: up to 5 Kg
- Time required to clean a room: 5-10mins*
- Water storage : up to 2 liters
- Micro-Controller: Arduino Mega
- Dirt storage: up to 500gms.

*Note: Some of the above mentioned Specifications are the results from the calculations from the best of our knowledge, actual time/units may vary.

## Circuit Diagram