# User and Product Manual Instructions

GNG 1103

# Design Project User and Product Manual

## Hydroponic Growcer System


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# List of Acronyms and Glossary

**Table 1. Acronyms**

| Acronym | Definition |
|---|---|
| CAD | Computer Aided Design |
| FMEA | Failure Modes and Effects Analysis |
| HGS | Hydroponic Growth System |
| MDF | Medium-density Fireboard |
| MOFSET | Metal–Oxide–Semiconductor Field-Effect Transistor |

**Table 2. Glossary**

| Term | Acronym | Definition |
|---|---|---|
| Arduino | N/A | An open-source hardware and software project containing both a microcontroller (programmable circuit board) and an IDE (integrated development environment built using Java) |
| Breadboard | N/A | A board used to build an experimental model of a circuit. |

| | | |
|---|---|---|
| Motor Controller | N/A | A device that acts an amplifier by connecting a motor to an external battery using a H-bridge control circuit, and connectors. |
| Motor Driver | N/A | A device that acts as an amplifier by connecting a motor to an external battery using a H-bridge control circuit, and connectors while providing feedback and error. detection. |
| Power Interface | N/A | Any external power supply such as a transistor, a relay, or a motor driver. |

# 1 Introduction

This User and Product Manual (UPM) provides the information necessary for types of users (all Growcer team members from beginner growers with no experience to experienced growers with years of experience to effectively use the Hydroponic Growcer System (HGS)>and for prototype documentation.

# 2 Overview

The Hydroponic Growcer System (HGS) was developed by Team A7 throughout the course of Fall 2022 with the aim of promoting time-saving automation and user friendliness, ensuring visual cleanliness, and maintaining proper safety measurements for the plants. The automation of the raft cleaning process maximizes the return of investment to our client by allowing for the team's labor to be directed towards other tasks.

The fundamental needs of the Growcer team are defined as a product that is: 1) automated in a way that ensures time-efficiency, 2) easy-to-use for even inexperienced team members, 3) able to clean all areas and contours of a board, and 4) able to fit within the designated area (48" x 72" for a wall mount, and 30" by 96" for a table mount).

The Hydroponic Growcer System (HGS) is a comprehensive product made with a focus on maintaining geometric alignment and leveraging mechanical systems to create an automated and powerful machine that cleans algae boards within half the time than could be accomplished by human labour.

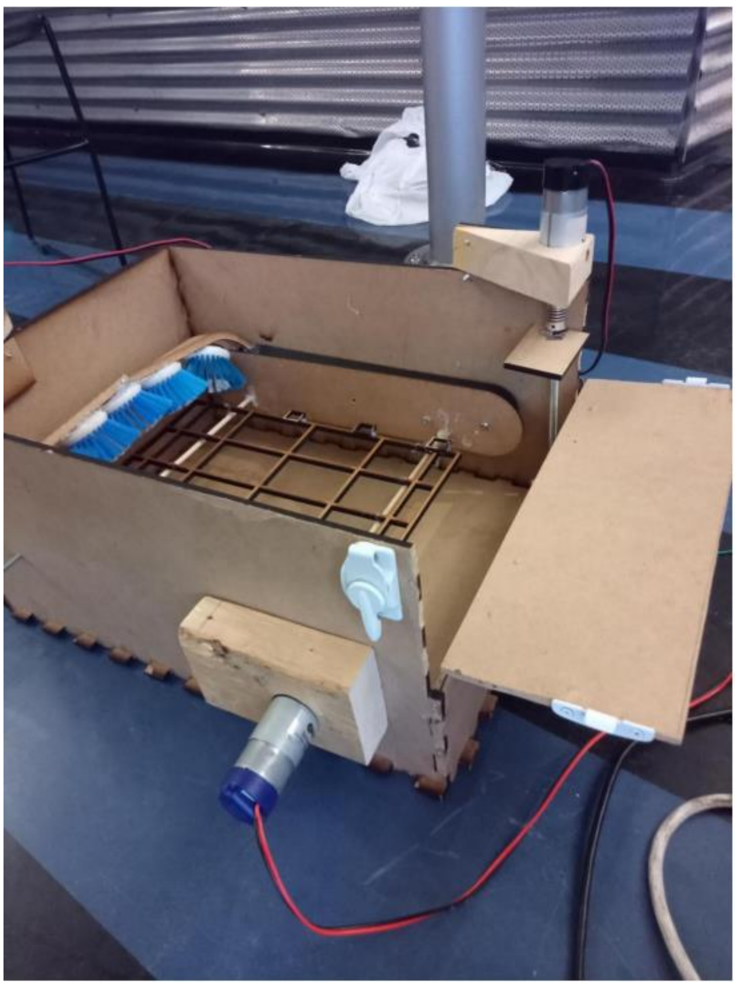


Figure 1. Photograph of Prototype III of the Hydroponic Growcer System.

The Hydroponic Growcer System is composed of a basic box frame built with five sides, a conveyer belt attached to the left and right sides of the box frames, a set of six surface area brushes which are attached by a horizontal plank to the conveyer belt, and a platform of 24 or more additional brushes, attached to an axis on two corners of the box, diagonal from each other. The cleaning subsystem of Prototype III is powered by 2 DC motors (for the brushes and conveyer belt), and 2 stepper motors (for the platform suspended on the z-axis). Both motors are powered by an external power supply, which is attached to a wall outlet. This electrical system was configured using the Arduino IDE (Integrated Development Environment), as well as an Arduino microcontroller and breadboard (**Table 3** in Section 6.1.2.).

## 2.1 Conventions

Paths to certain files are writing using Italics. For example, *Start >> This PC >> Documents >> Files*.

## 2.2 Cautions & Warnings

Before using any power interfaces, such as a power outlet or external power supply, please note that the power requirement of gear motors is 12V.

# 3 Getting started

## 3.1 Configuration Considerations

The equipment used for the cleaning subsystem of the HGS includes Arduino, a programming environment that is written in Java with support for C and C++ programming languages. Programs, called sketches, can be run on a PC connected to an Arduino board using a USB 2.0 Type A Plug attached to USB 2.0 Type B Plug Cable.

A DC motor and feather wing add-on is used with two bipolar stepper motors to power the brushes in the cleaning subsystem. A DC motor is an electric motor that converts electrical energy into mechanical energy for applications that require high revolutions per minute. This motor is coupled with an Arduino microcontroller (hardware component) and a power supply, which is required due to the low voltage and current output of the Arduino components.

## 3.2 User Access Considerations

Authorized members of the Growcer team with any range of experience who have undergone training by the organization are able to use and access the system.

## 3.3 Accessing/setting-up the System

Team members who have not been trained by a member of the design team on the electrical and power components should not attempt to configure or reconfigure the system's hardware.

## 3.4 System Organization & Navigation

To navigate the system, follow the steps below:

1. Plug in the cable to a wall supply (minimum of 12 Volts required).
2. Open the frame by pulling the handle towards you and rest the raft on the rectangular frame with a grid pattern (at the horizontal centre of the board).
3. Close the frame, making sure that it is completely closed.
4. Press the button to the right-hand side of the frame.
5. Keep the door closed until you hear the machine beep or blink three times.
6. Open the frame and retrieve the raft.

## 3.5 Exiting the System

To turn off the system, press the power button on the right-hand side of the frame.

# 4 Using the System

The following sub-sections provide detailed, step-by-step instructions on how to use the various functions or features of the Hydroponic Growcer System (HGS).

## 4.1 Given Cleaning Subsystem

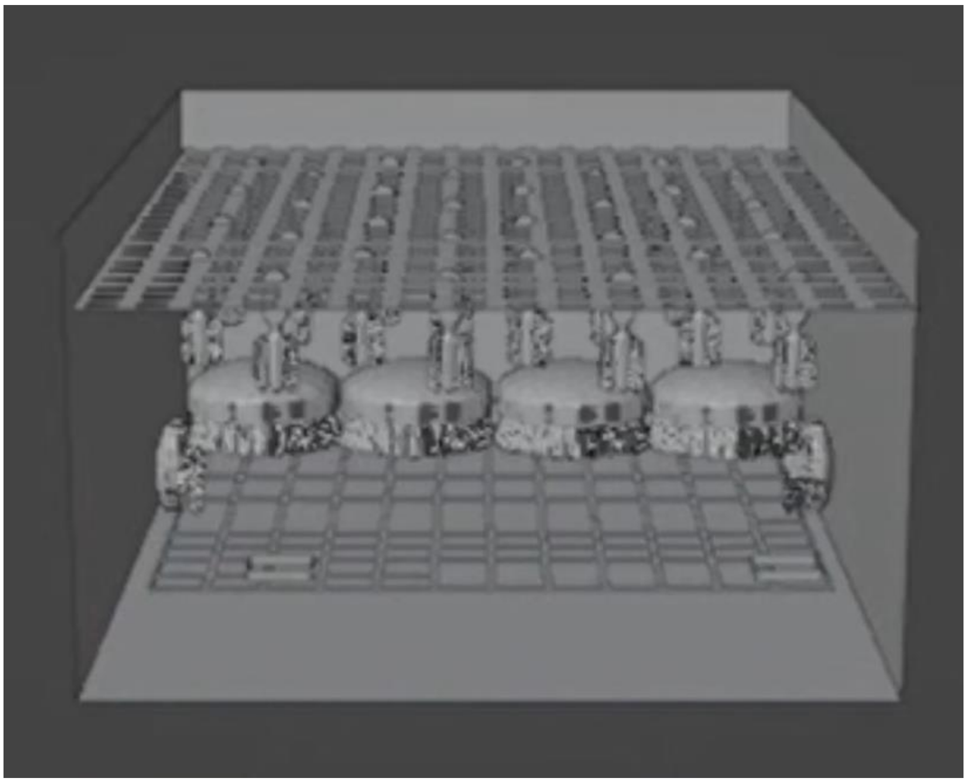


Figure 2. CAD drawing of final prototype facing grid and cleaning brushes.

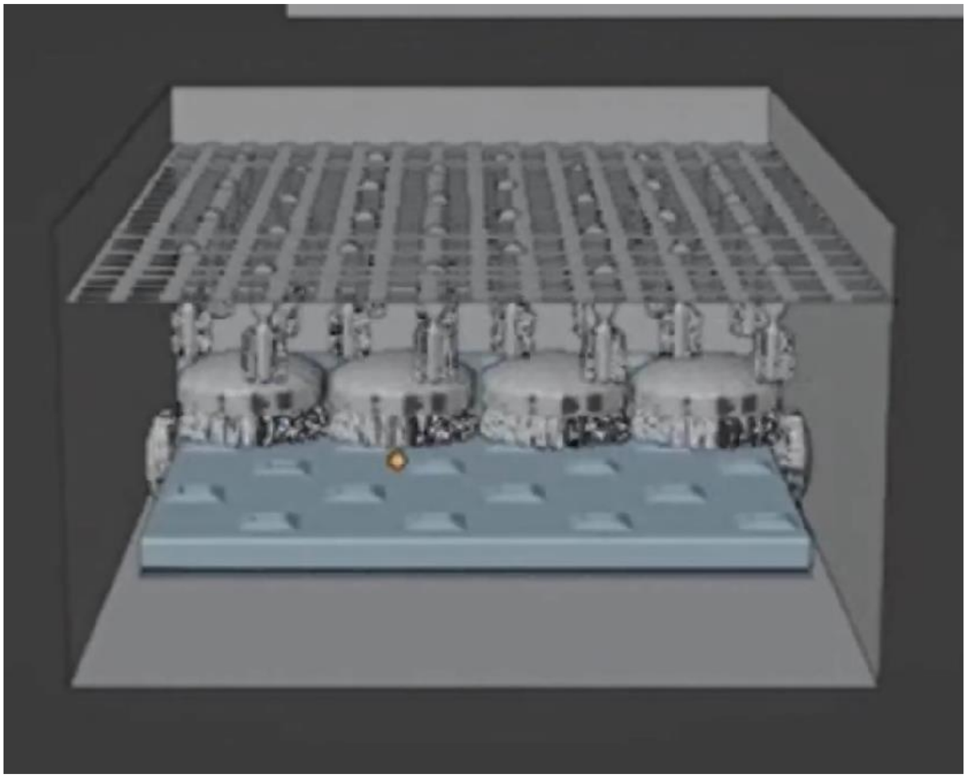


Figure 3. CAD drawing of final prototype facing raft on top of grid and cleaning brushes.

Once the door of the frame has been opened, insert the raft (2) on top of the grid (1), and close the door.

### 4.1.1 Given Power Components for Cleaning Subsystem

Motors are attached to the left and right sides of the frame, as shown by the circles attached to the grid (1). Engaging the motors is done by pressing the power button on the right-hand side of the frame.

# 5 Troubleshooting & Support

## 5.1 Error Messages or Behaviors

**Error 1:** The surface area brushes are not moving after the power button is turned on.

In case of Error 1, ensure the power cable is properly attached to the outlet. Check to see if there is visible damage to the wires. If the cable is properly attached and has no visible damage, please call for support.

**Error 2:** The platform is not moving after the surface area brushes are completed moving.

In case of Error 2, pull the emergency switch and check to see that the raft is properly aligned with the grid. If it is properly aligned, call for support.

**Error 3:** One or more gear brushes are jammed in the holes of the raft.

In case of Error 3, pull the emergency switch and call for support immediately.

## 5.2 Special Considerations

In case of fire, do not attempt to troubleshoot the HGS. Call immediately for help and evacuate if necessary.

## 5.3 Maintenance

To avoid failure, please check the power cables for damage before any use. To ensure that the frame is usable, store off the ground in a dry area with a temperature no higher than room temperature (20-24 degrees Celsius).

## 5.4 Support

For emergency assistance, contact Laila Burns directly by email (lburns039@uottawa.ca). The design team is working on an online ticketing system using Google Forms to report errors.

# 6 Product Documentation

The basic box frame was developed in Prototype I and is composed of 5 Medium Density Fireboard (MDF) Wooden Planks: the bottom (dimensions: 20x15 in.), the larger walls (dimensions: 20x10 in. each) and the smallest walls (dimensions: 15x10 in. each). This type of frame was chosen due to the accessibility of material and its compatibility with our current equipment (laser printer).

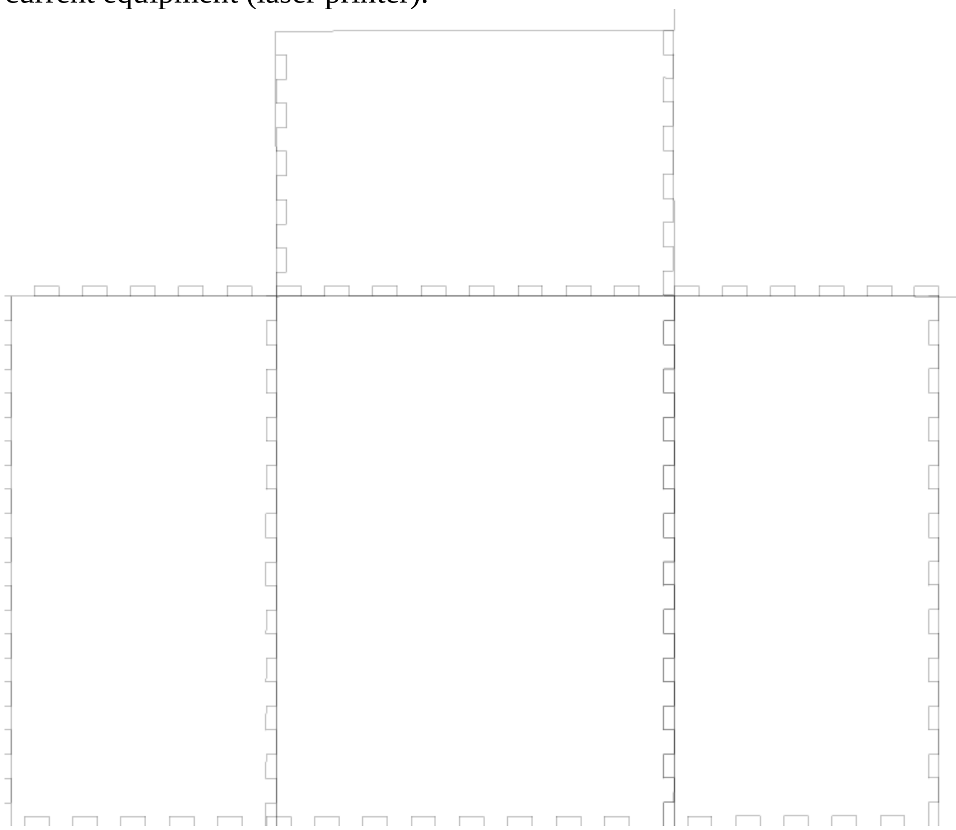


Figure 4. Draft of frame designed for laser cutting with MDF.

The cleaning subsystem was developed for Prototype I and amended for Prototype II in response to client feedback regarding the movement of brushes. It is made of six collated brushes, attached to a horizontally aligned rectangular plank which is attached at both ends to a conveyor belt (powered by two DC motors), which is attached to the left and right sides of the box frame.

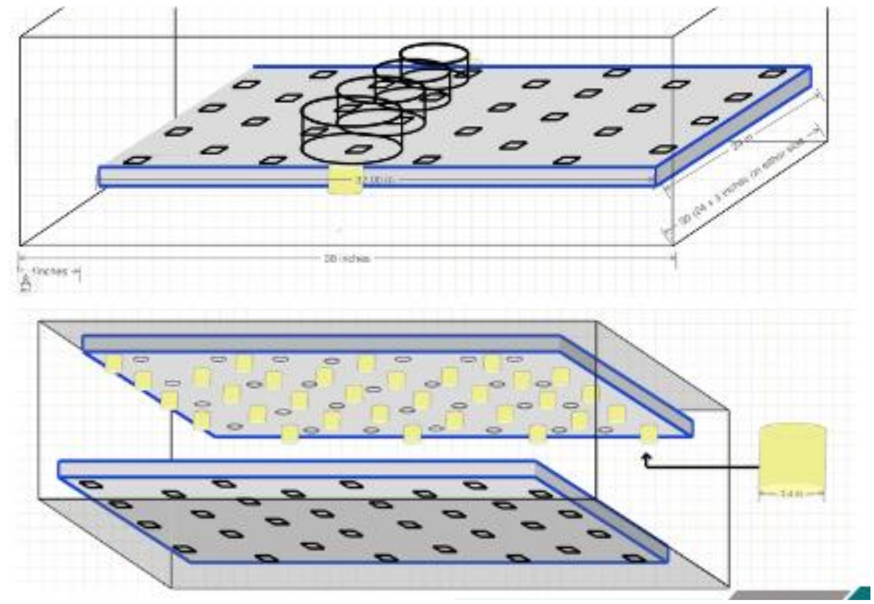


Figure 5. CAD drawings depicting cleaning subsystem.

A z-axis was added to the design concept for Prototype III to integrate the feedback mentioned above. This axis is attached to the two corners of the rectangular box frame, which also has 2 stepper motors attached to it, permitting the up-and-down movement of the platform at the press of a button. Additionally, the platform is attached by glue to laser-cut gears which are attached to brushes that are aligned geometrically with the holes in the raft, and the gears permit each brush to rotate at the same time as all other brushes on the platform. All the cables, motors and breadboards are connected to a power supply.

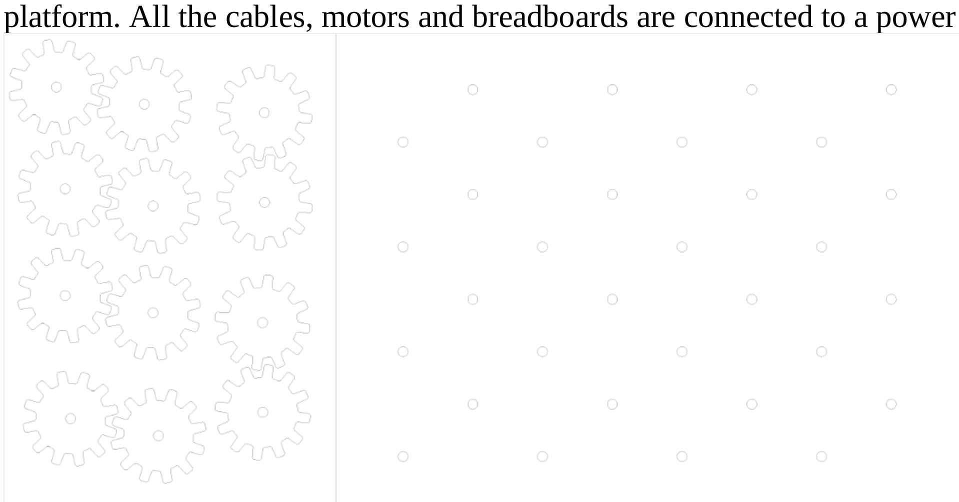
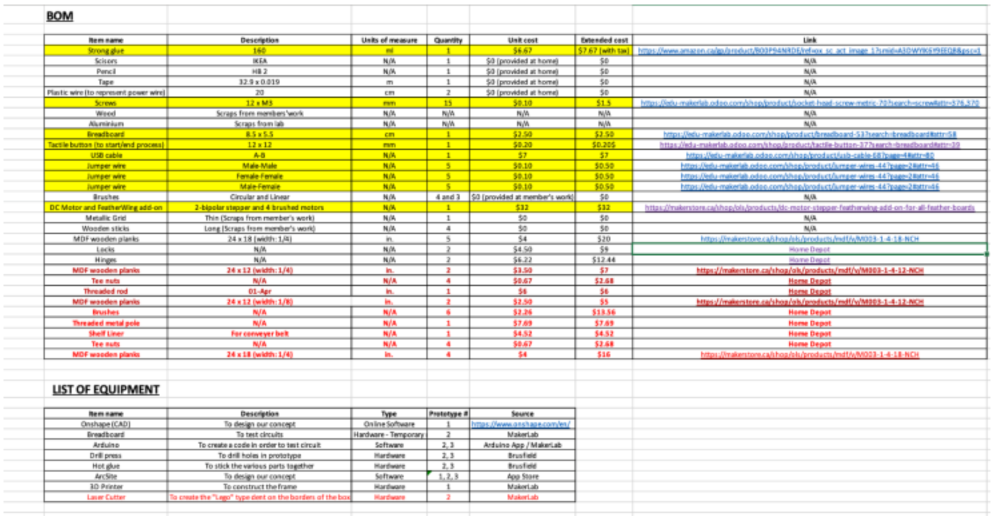


Figure 6. Platform made using gears designed to have attached thin brushes geometrically aligned with raft holes.

## 6.1 Subsystem 1: Cleaning Subsystem of HGS

### 6.1.1 BOM (Bill of Materials)

Please see the Bill of Materials (BOM) for Subsystem 1 below:



**BOM**

| Item name | Description | Units of measure | Quantity | Unit cost | Extended cost | Link |
|---|---|---|---|---|---|---|
| Strong glue | 160 | ml | 1 | $6.67 | $7.67 (with tax) | https://www.amazon.ca/gp/product/B00P94NRDE/ref=ox_sc_act_image_1?smid=A3DWYIK6Y9EEQB&psc=1 |
| Scisors | IKEA | N/A | 1 | $0 (provided at home) | $0 | N/A |
| Pencil | HB 2 | N/A | 1 | $0 (provided at home) | $0 | N/A |
| Tape | 32.9 x 0.019 | m | 1 | $0 (provided at home) | $0 | N/A |
| Plastic wire (to represent power wire) | 20 | cm | 2 | $0 (provided at home) | $0 | N/A |
| Screws | 12 x M3 | mm | 15 | $0.10 | $1.5 | https://edu-makerlab.odoo.com/shop/product/socket-head-screw-metric-70?search=screw#attr=376,370 |
| Wood | Scraps from members'work | N/A | N/A | N/A | N/A | N/A |
| Aluminium | Scraps from lab | N/A | N/A | N/A | N/A | N/A |
| Breadboard | 8.5 x 5.5 | cm | 1 | $2.50 | $2.50 | https://edu-makerlab.odoo.com/shop/product/breadboard-53?search=breadboard#attr=58 |
| Tactile button (to start/end process) | 12 x 12 | mm | 1 | $0.20 | $0.20$ | https://edu-makerlab.odoo.com/shop/product/tactile-button-37?search=breadboard#attr=39 |
| USB cable | A-B | N/A | 1 | $7 | $7 | https://edu-makerlab.odoo.com/shop/product/usb-cable-68?page=4#attr=80 |
| Jumper wire | Male-Male | N/A | 5 | $0.10 | $0.50 | https://edu-makerlab.odoo.com/shop/product/jumper-wires-44?page=2#attr=46 |
| Jumper wire | Female-Female | N/A | 5 | $0.10 | $0.50 | https://edu-makerlab.odoo.com/shop/product/jumper-wires-44?page=2#attr=46 |
| Jumper wire | Male-Female | N/A | 5 | $0.10 | $0.50 | https://edu-makerlab.odoo.com/shop/product/jumper-wires-44?page=2#attr=46 |
| Brushes | Circular and Linear | N/A | 4 and 3 | $0 (provided at member's work) | $0 | N/A |
| DC Motor and FeatherWing add-on | 2-bipolar stepper and 4 brushed motors | N/A | 1 | $32 | $32 | https://makerstore.ca/shop/ols/products/dc-motor-stepper-featherwing-add-on-for-all-feather-boards |
| Metallic Grid | Thin (Scraps from member's work) | N/A | 1 | $0 | $0 | N/A |
| Wooden sticks | Long (Scraps from member's work) | N/A | 4 | $0 | $0 | N/A |
| MDF wooden planks | 24 x 18 (width: 1/4) | in. | 5 | $4 | $20 | https://makerstore.ca/shop/ols/products/mdf/v/M003-1-4-18-NCH |
| Locks | N/A | N/A | 2 | $4.50 | $9 | Home Depot |
| Hinges | N/A | N/A | 2 | $6.22 | $12.44 | Home Depot |
| MDF wooden planks | 24 x 12 (width: 1/4) | in. | 2 | $3.50 | $7 | https://makerstore.ca/shop/ols/products/mdf/v/M003-1-4-12-NCH |
| Tee nuts | N/A | N/A | 4 | $0.67 | $2.68 | Home Depot |
| Threaded rod | 01-Apr | in. | 1 | $6 | $6 | Home Depot |
| MDF wooden planks | 24 x 12 (width: 1/8) | in. | 2 | $2.50 | $5 | https://makerstore.ca/shop/ols/products/mdf/v/M003-1-4-12-NCH |
| Brushes | N/A | N/A | 6 | $2.26 | $13.56 | Home Depot |
| Threaded metal pole | N/A | N/A | 1 | $7.69 | $7.69 | Home Depot |
| Shelf Liner | For conveyer belt | N/A | 1 | $4.52 | $4.52 | Home Depot |
| Tee nuts | N/A | N/A | 4 | $0.67 | $2.68 | Home Depot |
| MDF wooden planks | 24 x 18 (width: 1/4) | in. | 4 | $4 | $16 | https://makerstore.ca/shop/ols/products/mdf/v/M003-1-4-18-NCH |

**LIST OF EQUIPMENT**

| Item name | Description | Type | Prototype # | Source |
|---|---|---|---|---|
| Onshape (CAD) | To design our concept | Online Software | 1 | https://www.onshape.com/en/ |
| Breadboard | To test circuits | Hardware - Temporary | 2 | MakerLab |
| Arduino | To create a code in order to test circuit | Software | 2, 3 | Arduino App / MakerLab |
| Drill press | To drill holes in prototype | Hardware | 2, 3 | Brusfield |
| Hot glue | To stick the various parts together | Hardware | 2, 3 | Brusfield |
| ArcSite | To design our concept | Software | 1, 2, 3 | App Store |
| 3D Printer | To construct the frame | Hardware | 1 | MakerLab |
| Laser Cutter | To create the "Lego" type dent on the borders of the box | Hardware | 2 | MakerLab |

Figure 7. Screenshot of Bill of Materials for Subsystem I.

### 6.1.2 Equipment list

Please see the list of equipment required for the building of Subsystem 1 below:

**Table 3: List of Equipment**

| Item name | Description | Type | Prototype # | Source |
|---|---|---|---|---|
| Onshape (CAD) | To design our concept | Online Software | 1 | https://www.onshape.com/en/ |
| Breadboard | To test circuits | Hardware - Temporary material | 2 | MakerLab |

| | | | | |
|---|---|---|---|---|
| Arduino | To create a code in order to test circuit | Software | 2, 3 | Arduino App / MakerLab |
| Drill press | To drill holes in prototype | Hardware | 2, 3 | Brunsfield |
| Hot glue | To stick the various parts together | Hardware | 2, 3 | Brunsfield |
| Laser Cutting | To design small attributes for our prototype | Hardware | 2 | MakerLab |

### 6.1.3 Instructions

1. Construct a curved platform composed of laser cut MDF and glue six round bristled brushes on the top. The curved platform is designed to be 13-in long and 13-in weight, 1.5-in height, and the conveyer belt is designed to be 1-in wide, and 18-in long. The conveyer belt is made of shelf liner cut into strips glued together, and has two wheels which allow it to rotate, one attached to motor, and the other powered by tension.

2. Attach the curved platform to the motorized track.

3. Use the CAD drawings of gears (Figure 6) to construct the platform attached to the z-axis and attach a motor to gear. For the final prototype, we used DC motors and manually switched wires to change the direction of the power supply, for demonstration purposes only. This manual is intended for a product that uses stepper motors which can automatically change the direction of a power supply and only need the button to start the process and will be updated as the Prototype is updated.

4. Attach thin bristled brushes to the holes in each gear in Figure 6.

## 6.2 Testing & Validation

The testing for Subsystem 1 is outlined below for our three completed Prototypes.

### Testing for Prototype I

**Objective**

The main objective of the prototype is to determine how well the movement of our conceived subsystem for cleaning works. This is the objective we are looking to reach as we are unsure if the subsystem can achieve this (reducing risk) and to communicate how the subsystem will work to our clients and each other. To complete our objective, we will be looking to test for if the subsystem covers the entire area, measuring the area covered if some is missed, and timing how long it takes the subsystem to cover all the area it can.

**Test Procedure**

1. Once the prototype is built, set up a camera to record a video of the movement of the model.
2. Start recording the video and move the brushes at a constant speed.
3. Once the brushes have returned to where they have started, stop the recording to get the total time spent moving the brushes
4. Afterwards you may move the brushes at any pace and note down any areas missed by the brushes.
5. Now measure the size of the areas missed and subtract it from the total area of the board to get the area covered by the subsystem
6. Repeat any steps as necessary to record averages of data.

**Table 4: Table Documenting the Testing of Prototype I**

| Test Objective | Test Description | Results Wanted | Results Yielded |
|---|---|---|---|
| Test the cleanability | We are using a physical focused prototype consisting of a model of the cleaning subsystem concept. | Holes of board should be completely cleaned.<br>Whole area of board should be visually clean. | Holes of board are completely clean.<br>All areas except for the left and right borders are visually clean (fail). |
| Test the time efficiency | | The whole area of the board should be | The whole area of the board is visually clean |

| | | | |
|---|---|---|---|
| | | visually clean in less than 6 hours. | in under 15 seconds. |

### Testing for Prototype II

### Objective

The main objective of the prototype was to measure the performance of the frame subsystem; therefore, we won't go into detail regarding the test procedure and results.

**Table 5: Table Documenting the Testing of Prototype II**

| Test Objective | Test Procedure | Test Description | Results Wanted | Results Yielded |
|---|---|---|---|---|
| Check to see if the "Lego" frame properly aligns the board | Numerically determine whether the frame will align with the board, and physically test this. | Physical/analytical, medium fidelity. | Dimensions of frame should be less than or equal to dimensions of the board. | The dimension of the box is 10x15x20 in., with the interlocking "Lego" dents being distanced by 1 in. from each other.<br>As predicted mathematically, the walls of the box fit correctly into each other (the "Lego" dents), and the hinges correctly hold the door/wall in place (regardless of its usage). |

| | | | | |
|---|---|---|---|---|
| Test how easy it is to put the board into the box (frame) | Multiple physical models to represent methods of putting the board in the box (from above, in a slit in the side, etc.) | Estimate time spent to put it in to determine the model. | No predetermined range.<br>Fits perfectly inside the box, without trouble. | The board (dimensions: 14x9.3 in.) fit perfectly inside the box (on top of the grid).<br>It takes around 5 seconds to insert the board and to place it on top of the grid. |

**Testing for Prototype III**

**Objective**

The main objective of the prototype was to reduce the risks associated with our final prototype, measure the performance of the cleaning system, and communicate the efficiency of the whole system to the client.

**Table 6: Table Documenting the Testing of Prototype III**

| Test Objective | Test Procedure | Test Description | Results Wanted | Results Yielded |
|---|---|---|---|---|
| Determine a method to spin each brush of the cleaning subsystem at a fast enough speed to clean the board. | Physical model with higher fidelity (important test) of brushes hooked up to DC motors. | Record the speed of each brush to find the average speed of all brushes. Also note any brushes that do not spin. This will help us determine the type of brushes, motors and axles needed. | Testing these brushes may take a long amount of time as the brushes need to spin for a long time to measure cleaning performance. | The brushes unfortunately do not spin because the DC motors we used do not permit making the brushes go all around and spin at the same time. |

| | | | | |
|---|---|---|---|---|
| Figure out if there are any compatibility issues between the three subsystems. | Physical models of the cleaning (lower fidelity), holes and frame subsystems that are wired up to a controller to allow movement. | Results of the prototype include any collision between subsystems and the lengths of subsystems that are too big for the frame. | Once subsystems are assembled testing for compatibility won't take long. | All the subsystems are compatible to one another: the cleaning of the holes does not compromise the cleaning of the board. |
| Test for the amount of water that can drain from the box. | Using the medium fidelity physical model from prototype 2 combined with a testing device containing water. | Using the medium fidelity physical model from prototype 2 combined with a testing device containing water. | Since it will only require a slight modification to the model from prototype 2 little time will be spent testing this. | We ended up not using water, as it was mentioned that it wasn't allowed for Design Day. If we were to use some, we would use the drainage established during the last prototype. |
| Test for percentage of the board cleaned (related to brush speed and coverage). | Analytical model with high fidelity. Calculations for how much algae will remain after a given time of the brushes running. | Results will be the percentage of the board cleaned of algae. Used to determine the performance of the entire project. | Will take a while to consider all parts of the prototype in the calculations. All forces must be accounted for. | We achieved a total cleanliness percentage of 86.18% by calculating the flat area of each surface of the board (top, bottom…) and if most of the sides would get cleaned except for most of the left and right sides. This brought us to a 90% cleanliness, and we divided that by the total area of the |

| | | | | |
|---|---|---|---|---|
| | | | | surface. It must be noted that this is only an estimate. |

# 7 Conclusions and Recommendations for Future Work

Summarize your lessons learned and your work related to your prototype and suggest the most productive avenues for future work so that other groups can continue and improve upon your work.

The main area to focus on for improvements to the design is the Prototype III. This final prototype was constructed with all functional parts of the design except for the spinning motors of the brush subsystems. Because of the incomplete prototype and time constraints, not all test plans for the prototype were executed. The first test and third test outlined in **Table 6** need to be completed as the brushes were not able to spin and the machine did not contain a water draining system respectively. For future work, these tests should be implemented on the prototype and further tests of the percentage of clean should be run to get more accurate results. Another thing we would add given more time is an analytical prototype.

# 8 Bibliography

"GNG2101 Chariot- Arduino Programming." *MakerRepo*, University of Ottawa Faculty of Engineering, 29 Jan. 2017, https://makerepo.com/jboud030/gng2101-chariot-arduino-programming.

# APPENDICES

# 9 APPENDIX I: Design Files

**Table 3. Referenced Documents**

| Document Name | Document Location and/or URL | Issuance Date |
|---|---|---|
| Project Deliverable B | Project Files at https://makerepo.com/clude023/1422.gng1103-a07-hydroponic-growcer-by-algae-annihilators- | |
| Project Deliverable C | Project Files at https://makerepo.com/clude023/1422.gng1103-a07-hydroponic-growcer-by-algae-annihilators- | |
| Project Deliverable D | Project Files at https://makerepo.com/clude023/1422.gng1103-a07-hydroponic-growcer-by-algae-annihilators- | |
| Project Deliverable E | Project Files at https://makerepo.com/clude023/1422.gng1103- | |

| | | |
|---|---|---|
| | a07-hydroponic-growcer-by-algae-<br>annihilators- | |
| Project<br>Deliverable F | Project Files at<br>https://makerepo.com/clude023/1422.gng1103-<br>a07-hydroponic-growcer-by-algae-<br>annihilators- | |

# 10 APPENDIX II: Other Appendices

This appendix contains detailed design drawings of our design taken from Project Deliverable E.

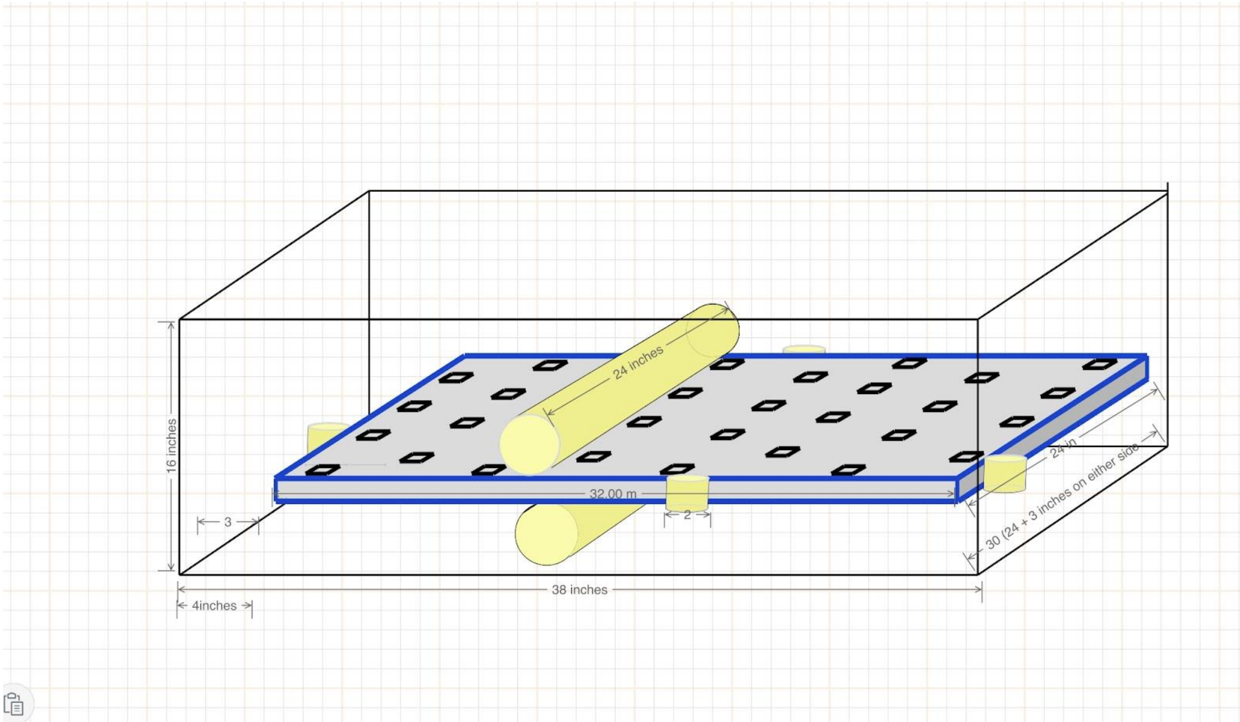



Figure 8. This image depicts our first subsystem which consists of six cylindrical brushes meant to clean the outer surface area of the board. These brushes will be made of an outer layer of toothbrush-like bristles in order to scrub off the algae. They will spin rapidly in a circle and move across the surface multiple times in order to ensure cleanliness.

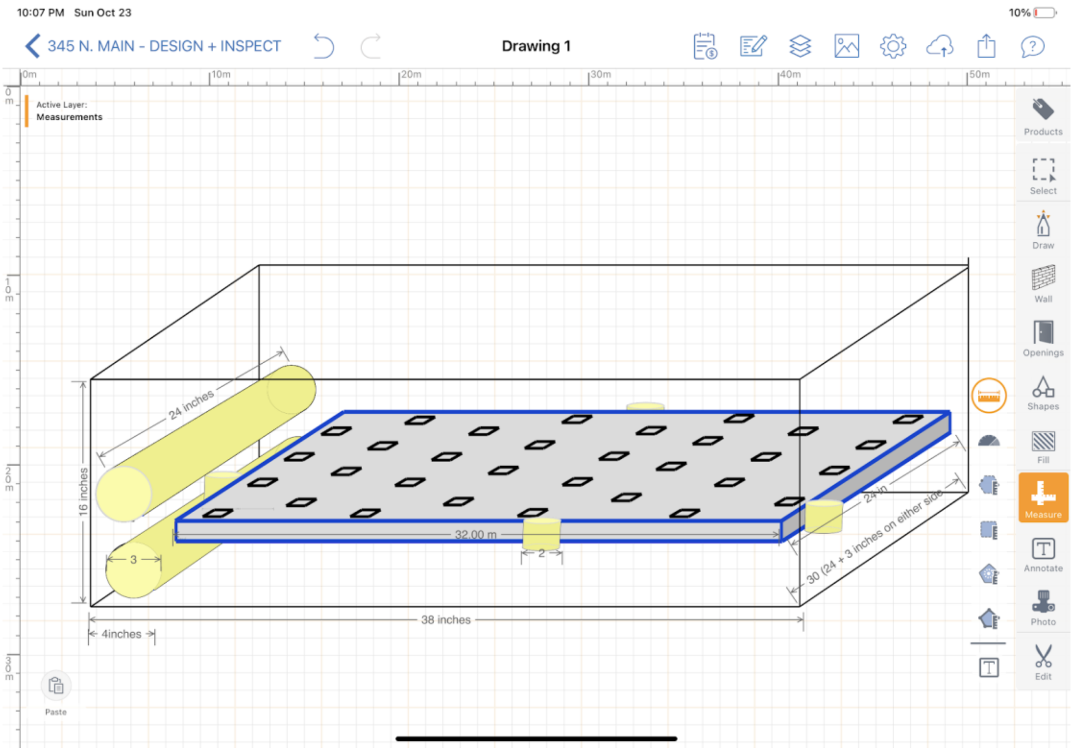



Figure 9. Brushes are out of the way with room for Subsystem two inner hole brushes.

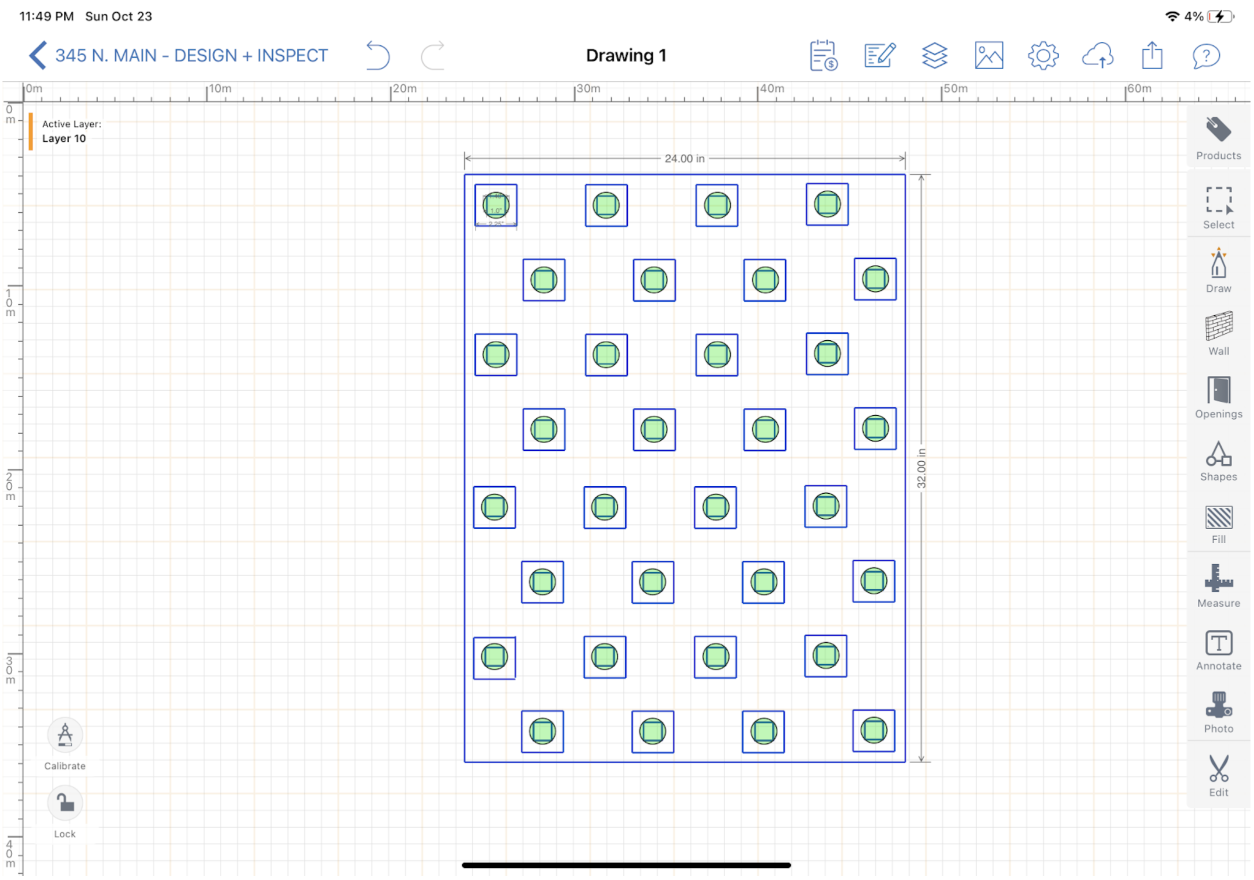



Figure 10. Accurate depiction of raft, holes, and area brushes will cover. The outer squares are the raised portion of the holes, and the inner square is the actual hole in the raft. The green circles portray the area of the brushes in comparison with the square.

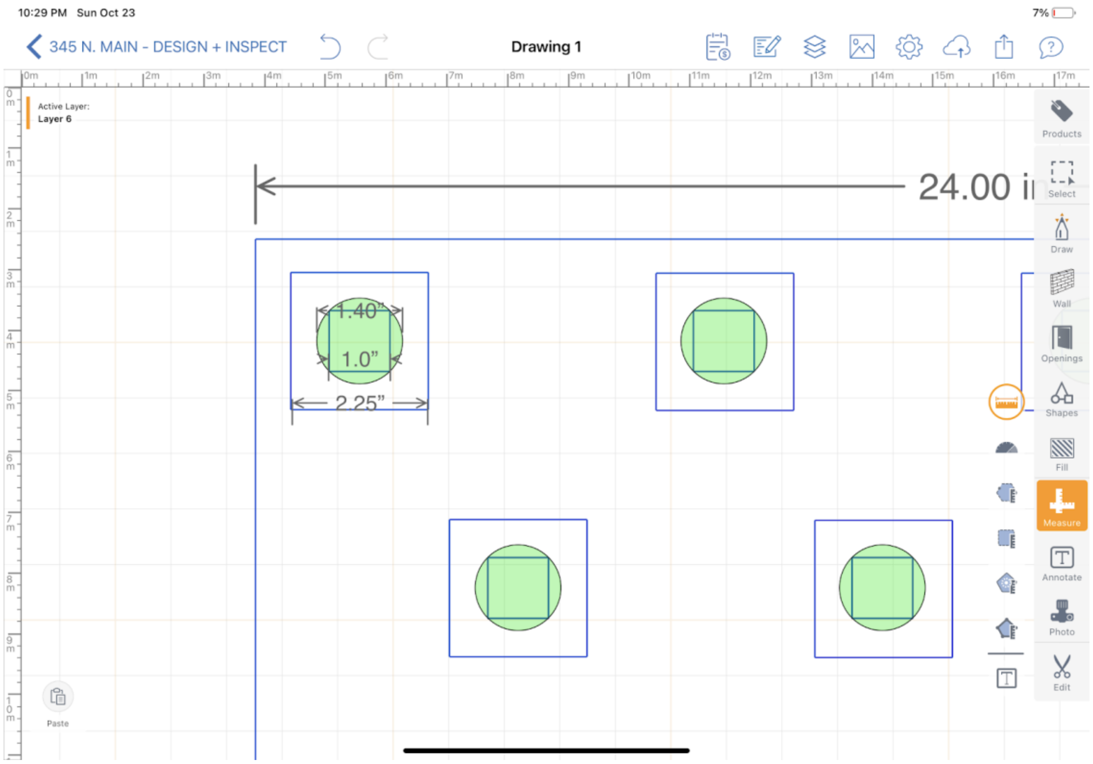



Figure 11. Close up version of holes.

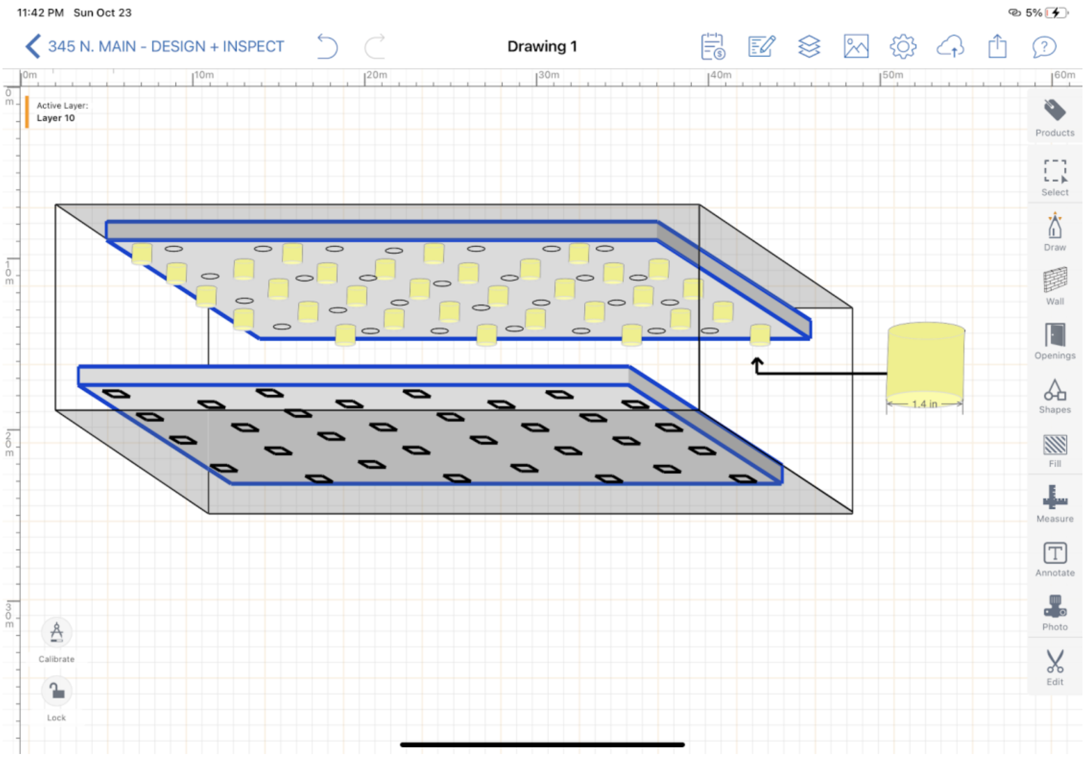



Figure 12. These brushes, in yellow, made of the same material as the brushes for subsystem 1, are pliable and can be squished into the squares while spinning, ensuring that the whole hole gets cleaned.

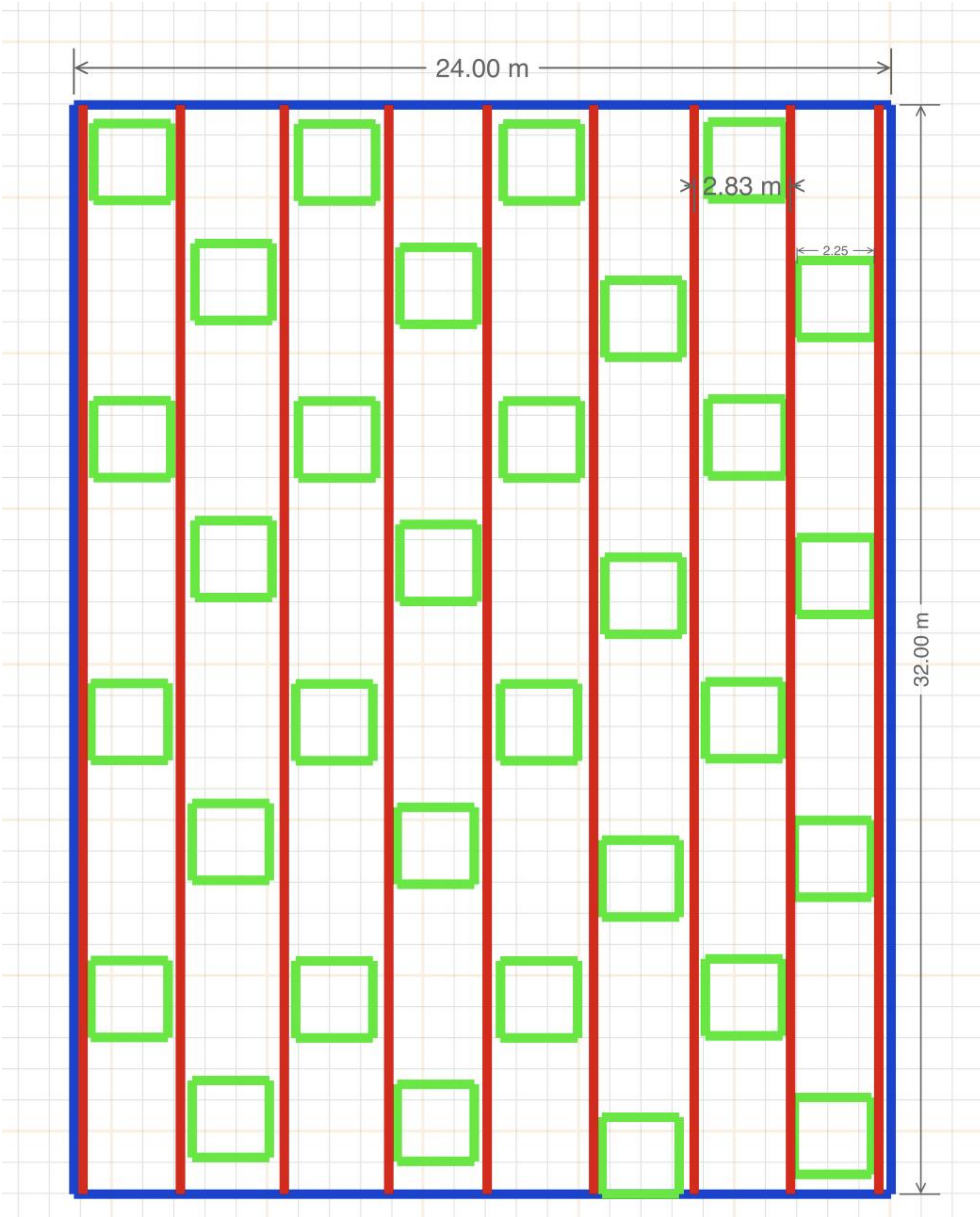

24.00 m
2.83 m
2.25
32.00 m

Figure 13. This is a depiction of our placement method for the raft. The raft will sit on a metal grid (see Figure 7 for details) with raised squares that will fit inside of the 0.25-inch indent in the bottom of the boards (See Figure 8) in order to get it in exactly the right position for the hole brushes to fit into the board.

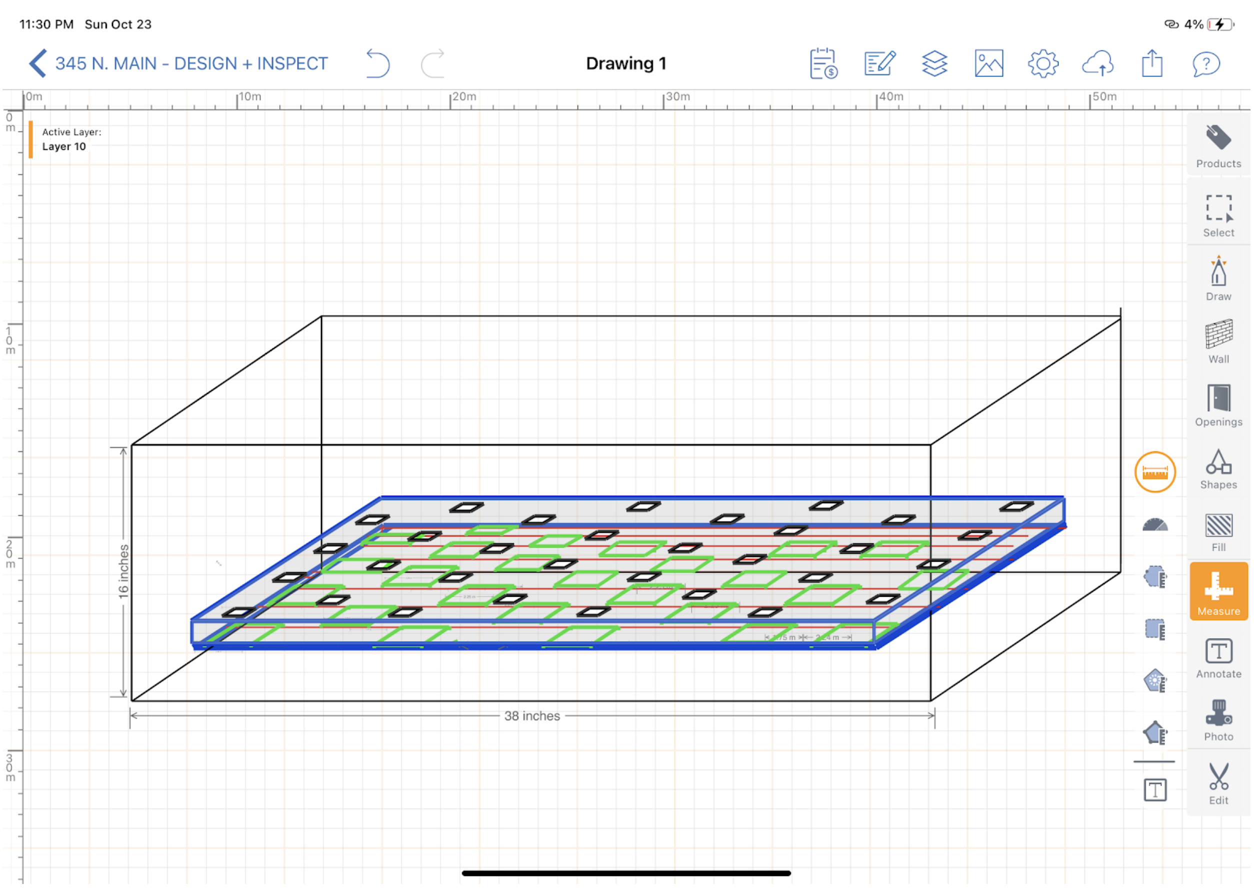



Figure 7. Visual depiction of tray under board.