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Modeling, Designing and Simulation of Grow Box

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Abstract

Grow Box is partially or completely closed system to grow plants.To grow plants in closed box, environment needs to be provided. The existing Grow Box has all the necessary properties and has potential to be a product. It is now time to put everything in order, in terms of hardware, a good water container, flexibility and its structure. By doing this not only it will make market appealing, but also brings in an design attitude towards project development cycle. This report contains process to design the Grow Box outer structure along with flow simulation of air inside the system. It also contains the step by step process to assemble the Grow Box.

Completion status

Two version of Grow Box has been designed. Fabrication of version1 is not feasible due to its complex design. Version2 has been fabricated with all the Electronics hardware.

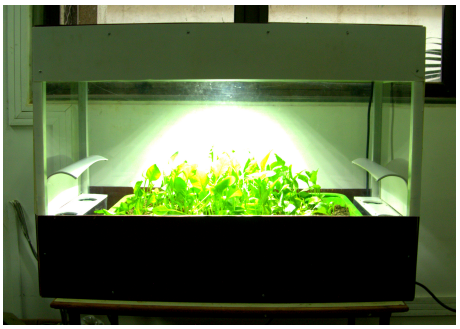


Figure 1.1: Current Working Model

1.1 Modeling and Designing

While designing the Grow Box following points have been considered

- Air Circulation
- Temperature Control
- Light Positioning
- Size
- Modularity
- Cost
- DIY Design
- Aesthetics

1.1.1 Grow Box V0

This is first prototype to be fabricated for testing purpose. This model consists of L shaped aluminum extrusion as framing structure, joined with fasteners.

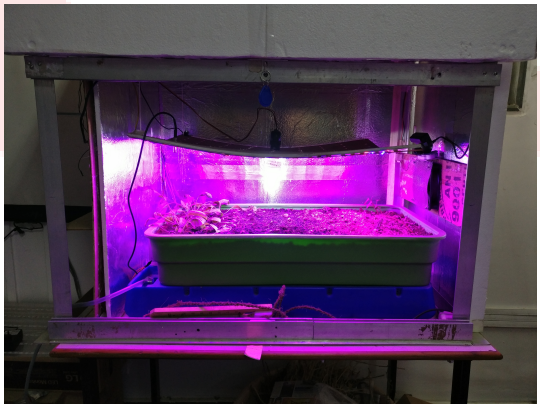


Figure 1.2: Grow Box V0

Air Flow Simulation in Grow Box Version0 in Solid Works.
This design consists of one inlet fan and one exhaust fan situated on the side

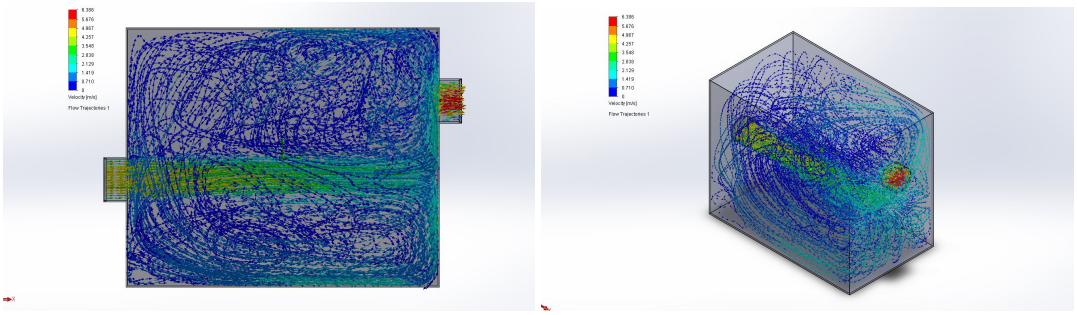


Figure 1.3: Air Flow Simulation in V0

wall of Grow Box. inlet fan is at lower position than exhaust fan. The flow of air is not proper as air comes from inlet and directly hit the other side of wall.

1.1.2 Grow Box V1

This is the first version and is designed in Autodesk Fusion 360. This design consists of aluminum tube and 3 way, 4 Way, 5Way connectors as framing structure. It has provision of light positioning and water storage. This model has more space for electronics hardware positioning. The door is attached to the model with the help of magnets. There is also provision of water storage at the bottom.

To see the 3D Model Click

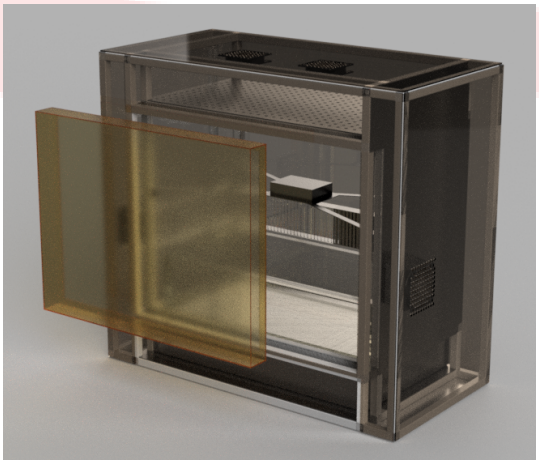


Figure 1.4: Grow Box V1

Air Flow Simulation in Grow Box Version1 in Solid Works. This model consists of two inlet points, situated at the side walls and two exhaust point, situated at the top panel. To allow proper distribution of inlet air, duct is provided. This allow air to come from all directions. There is also perforated pseudo top panel to allow air to exit from everywhere, instead of one point exit.

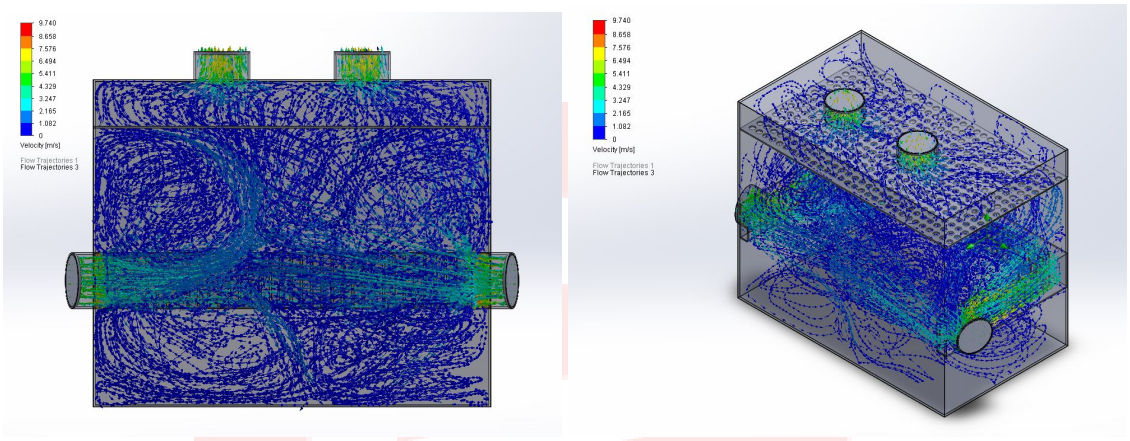


Figure 1.5: Air Flow Simulation in V1

Advantages of version1 are as follows:-

- Good air flow inside the Grow Box.
- This design is modular. So, it can be stacked vertically or horizontally by just changing the Aluminum Tube with MS Tubes.
- Water storage facility is present.
- Light position can be changed as required
- DIY Design.

The disadvantage of this model are as follows-

- The cost of fabrication of this model is high due to complex design.
- This design is bigger in size compared to existing model.

1.1.3 Grow Box V2

This is the Second version and is designed in Autodesk Fusion 360. This model has been fabricated. Framing structure of this model is done using aluminum tube and 3 way connectors. The supporting structure is 6mm thick acrylic sheets. Transparent acrylic is provided from all four side to provide aesthetic look. Top and bottom portion have opaque acrylic to hide the electronic components.

To see the 3D Model Click

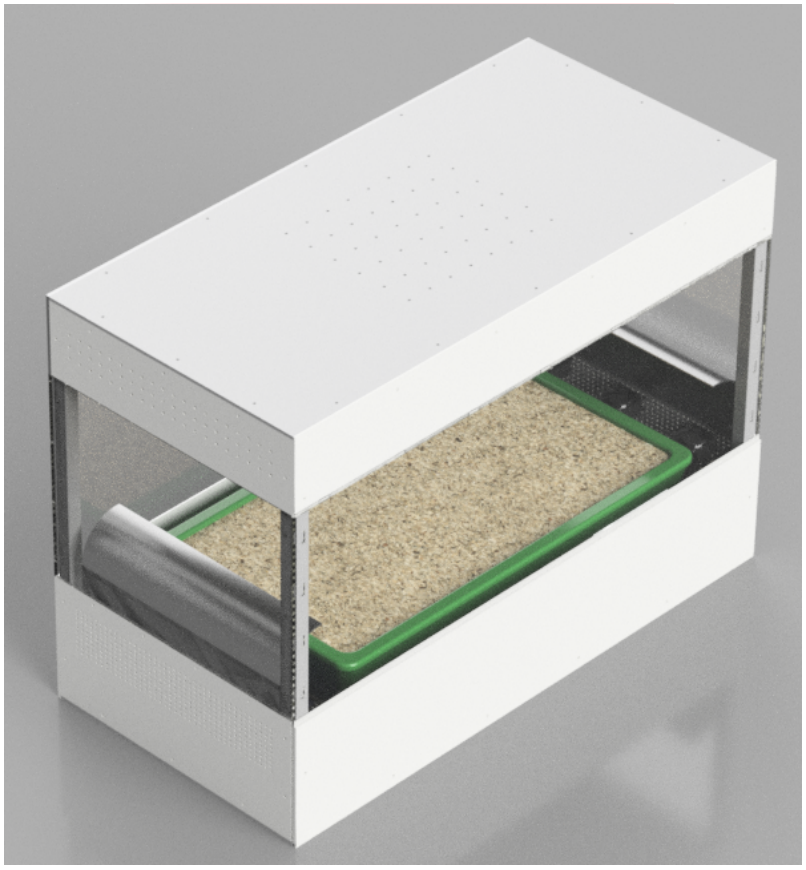


Figure 1.6: Grow Box V2

Air Flow Simulation in Grow Box Version2 in Solid Works. In this only inlet fans are provided. Fans are located at horizontal plane. Curved panel is used to change the direction of air. Outlet openings are provided in side walls and top walls. In this the air comes from inlet point and strikes the curved panel and then flows toward the plant and LED lights. Thus, allowing air to flow

over plants as well as cool the LED flood lights and then exit through outlet points.

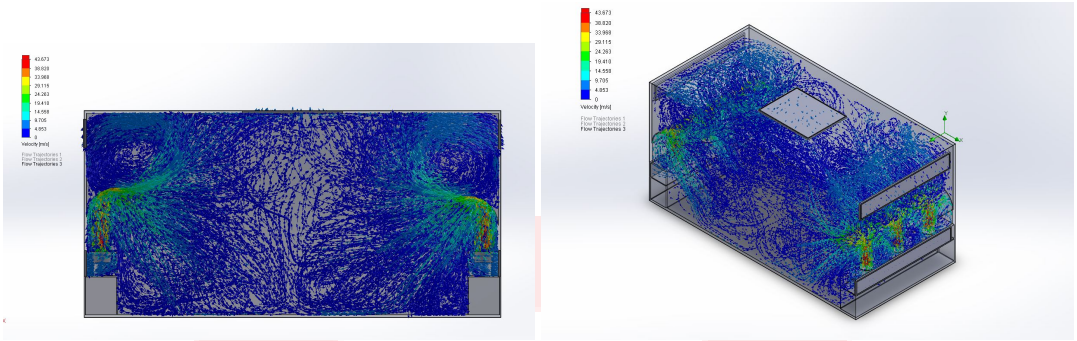


Figure 1.7: Air Flow Simulation in V2

Reasons why this model has been fabricated-

- Good air flow inside the Grow Box.
- Less cost compared to version1 design.
- DIY design, as design is not complex, so anyone can assemble it with ease.
- This design is modular. So, it can be stacked vertically or horizontally by just changing the Aluminum Tube with MS Tubes.
- This design is smaller in size compared to existing and version1 model.

The disadvantage of this model are-

- There is no provision of water storage. So water level have to be checked regularly.
- This design have no provision for exhaust fans. In this design number of inlet fans have been increased to compensate for exhaust fans.

1.2 Hardware parts

1.2.1 List of hardware

1. Square Aluminum Pipe

2. Square Connectors
3. Clear Acrylic Sheets
4. Opaque Acrylic Sheets
5. Fasteners
6. Magnets
7. Aluminum or Mild Steel Strips
8. Axial Flow Fans
9. Sunboard or Foam Board
10. Brackets

1.2.2 Detail of each hardware:

Different parts of Grow Box are as follows:

1. Square Aluminum Pipe Vendor link,
   Aluminum Square tubing is used as supporting structure because of its light weight, relative strength, superior resistance to corrosion and easy to work with properties.
   When vertical stacking is needed these Aluminum tubing can be replaced by High strength steel pipes due to more relative strength.
   (a) Tube 93.2

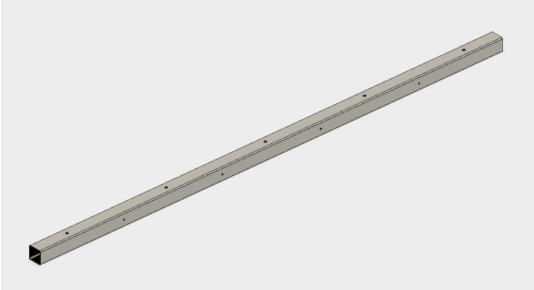


Figure 1.8: Aluminum Tube 932 mm

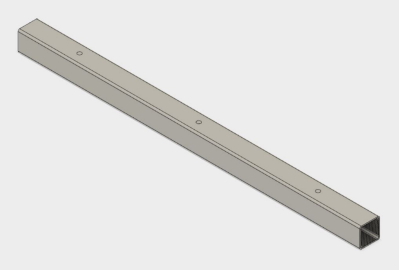


Figure 1.9: Aluminum Tube 430 mm

(b) Tube 43

(c) Tube 65

Figure 1.10: Aluminum Tube 650mm

2. Square ConnectorsVendor link,
   No fasteners are required to fix them, friction holds the framing together. This makes it easy to use and anyone can join these like Lego blocks.

   (a) 3 Way 90deg Elbow Square Connectors

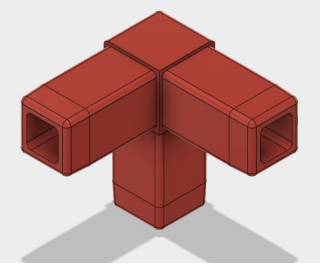


Figure 1.11: 3 Way Connectors

3. Clear Acrylic Sheets
   These provide clear view of the plants inside. These are mainly provided for aesthetic look. These also acts as supporting structures.
   Front mid panel is attached to the framing structure using magnets. This can be removed when needed.

   (a) Front Mid Panel

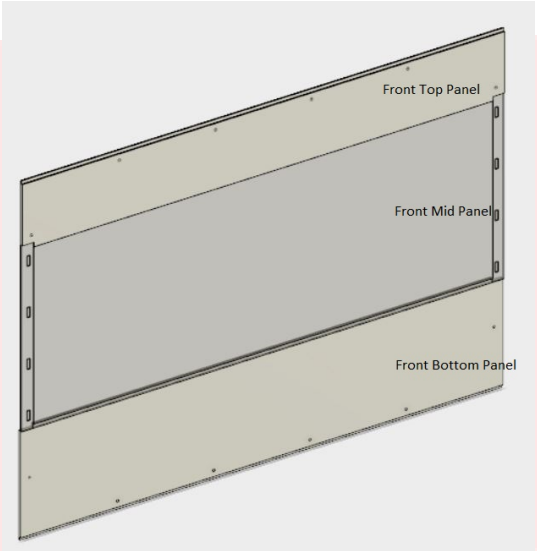


Figure 1.12: Front Panel

   (b) Rear Mid Panel

   (c) Right Side Mid Panel

   (d) Left Side Mid Panel

   (e) Side Curve Panel

4. Opaque Acrylic Sheets
   These are used to hold the outer aluminum structure together and thus acting as supporting structures.These are attached to the aluminum tubes using screws. These are opaque to hide the turf, electronics and lights.

   (a) Front Top Panel

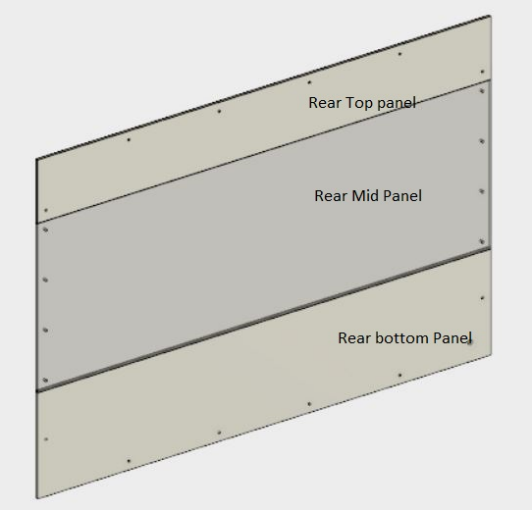


Figure 1.13: Rear Panel

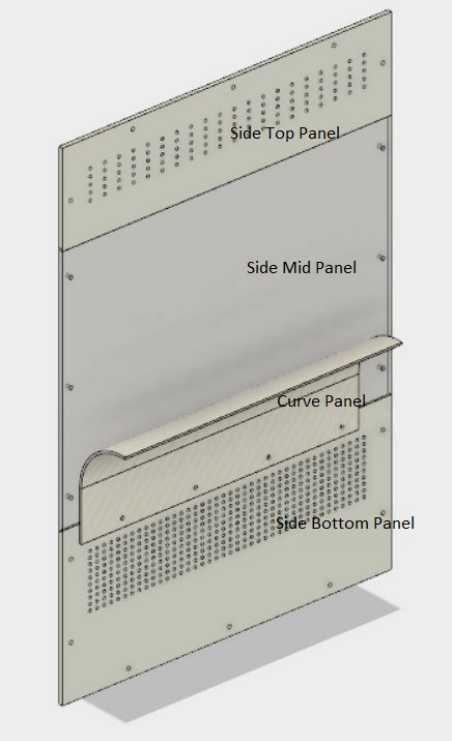


Figure 1.14: Side Plane

(b) Front Bottom Panel
(c) Rear Top Panel
(d) Rear Bottom Panel
(e) Right Side Top Panel
(f) Right Side Bottom Panel
(g) Left Side Top Panel
(h) Left Side Bottom Panel
(i) Top Panel

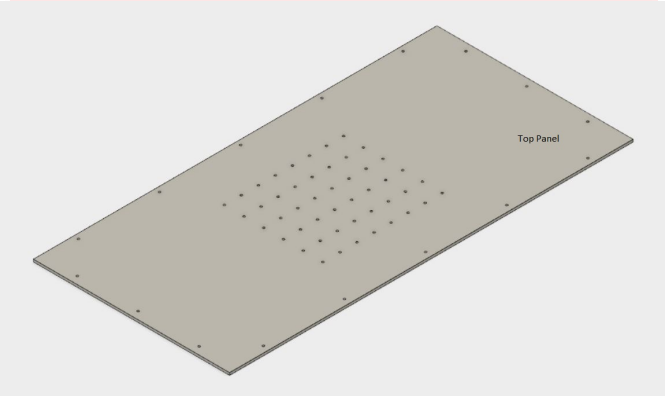


Figure 1.15: Top Panel

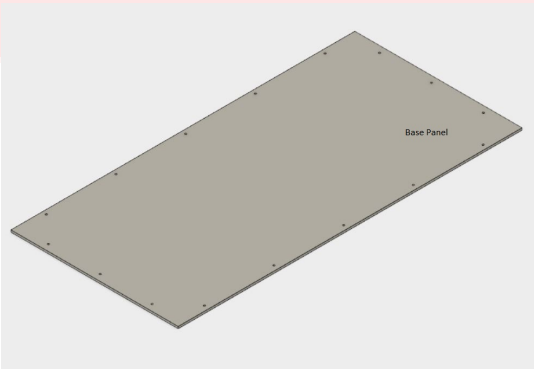


Figure 1.16: Base Panel

(j) Base Panel

(k) Component Box Panels

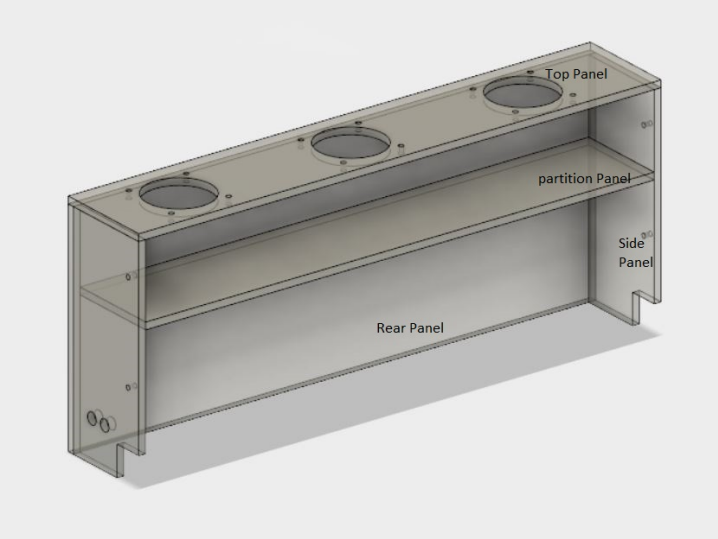


Figure 1.17: Component Box Panel

i. Top Panel
ii. Side Panel
iii. Rear Panel
iv. Partition Panel

5. Fasteners
   Fasteners are used to attach acrylic sheets to aluminum tubes together.

   (a) Screw
   Diameter of the screw used here is 1/8 inches.

   (b) Screw Bolts
   Its size depend on fans being used.

   (c) Screw Nuts

6. MagnetsVendor link,
   These are used to hold the front mid panel. Using these removes latches to hold the panel, thus removing any protrusions.

7. Mild Steel/Aluminum Strips
   These are used to hold the LED Flood Lights.

(a) Light Holders

8. Sun Board or Foam Board
   Sunboard acts as sealing agent by not allowing the air inside to leak from sides

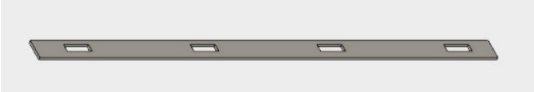


Figure 1.18: Sun Board Sealing Agent

9. Axial Flow FansVendor link,
   An axial fan is a type of a compressor that increases the pressure of the air flowing through it. The blades of the axial flow fans force air to move parallel to the shaft about which the blades rotate.

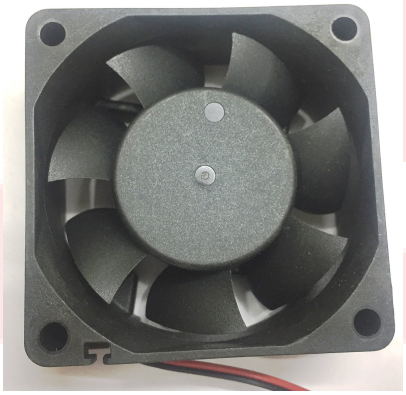


Figure 1.19: Inlet Fans

Product specification voltage: 12v current: 0. 12 - 0. 21 a dimensions: 60 x 60 x 25 mm (lxwxh) DC brushless motor fan brand can be different as shown in picture but other features and dimensions will remain same. Application: Cnc, robotics, DIY projects, computer cases, power supplies, 12v circuits where cooling is required. Package include: 1 x 60x60x25mm cooling fan.

1.3 Assembly of hardware

Steps of assembly of hardware with pictures for each step.

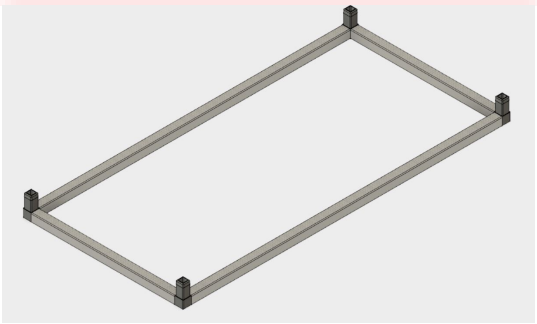
Steps to Assembly

Step 1

Press fit the 3 way joint to aluminum tube and hammer with a rubber mallet.

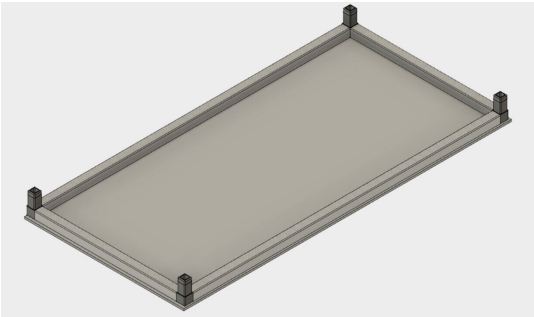
Step 2

Similarly press fit the other 3 way joint to aluminum tube and hammer with a rubber mallet.



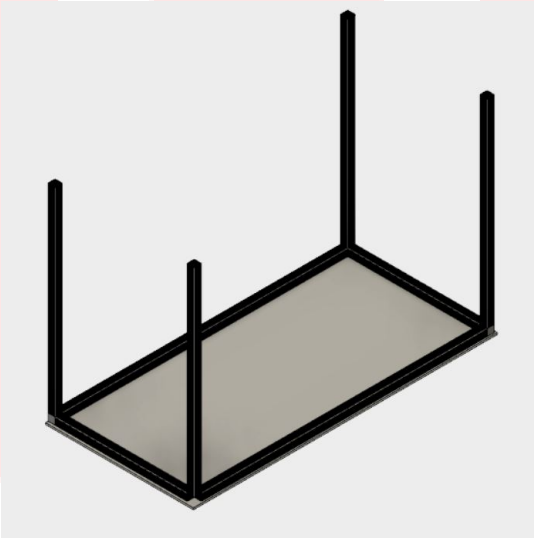
Step 3

Fix the base panel to the frame using screws.



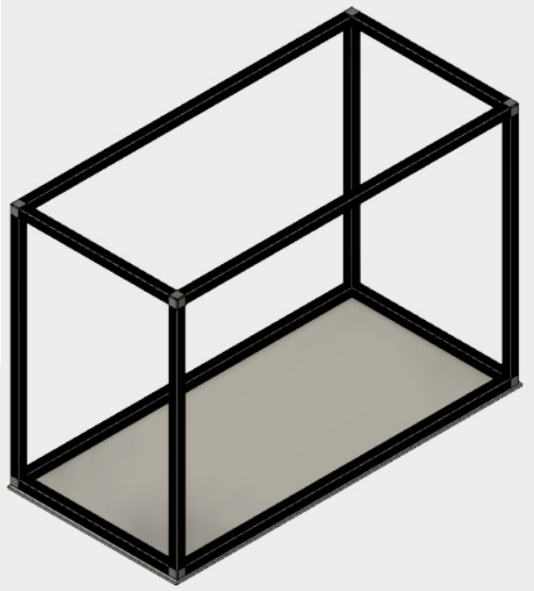
Step 4

Press fit the vertical aluminum tubes to the 3 way connectors and hammer with a rubber mallet.



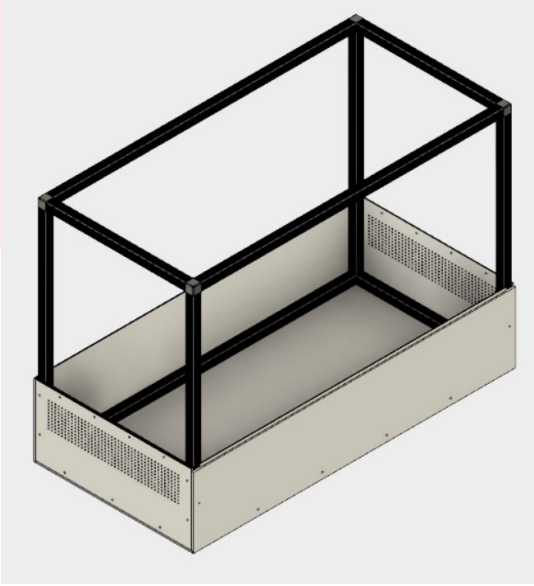
Step 5

Similarly press fit the top frame with 3 way joint to aluminum tube and hammer with a rubber mallet.



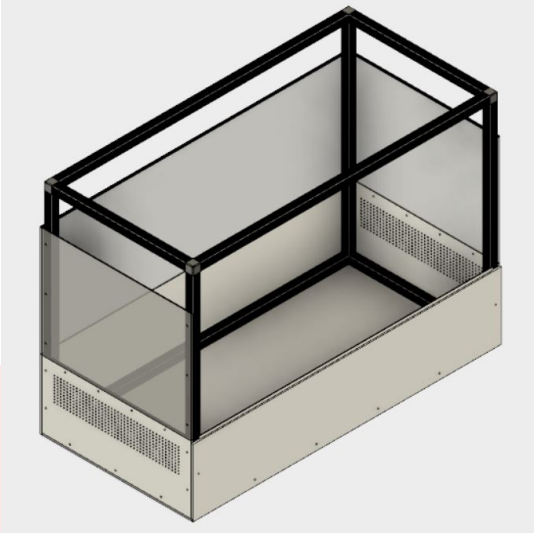
Step 6

Fix the bottom panels of front, rear and sides to the frame using screws.



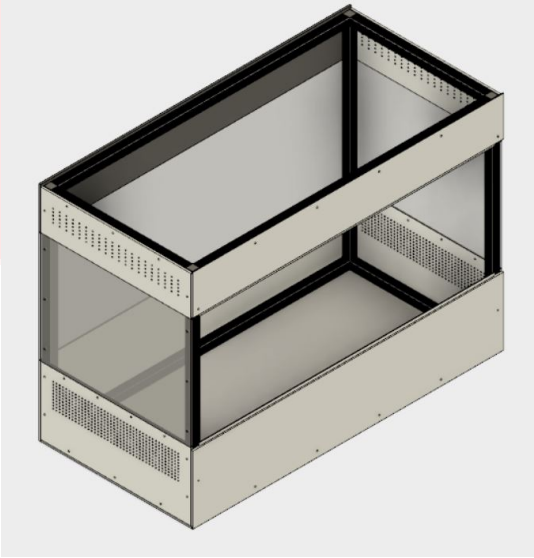
Step 7

Attach the mid panels of rear and sides to the frame using screws.



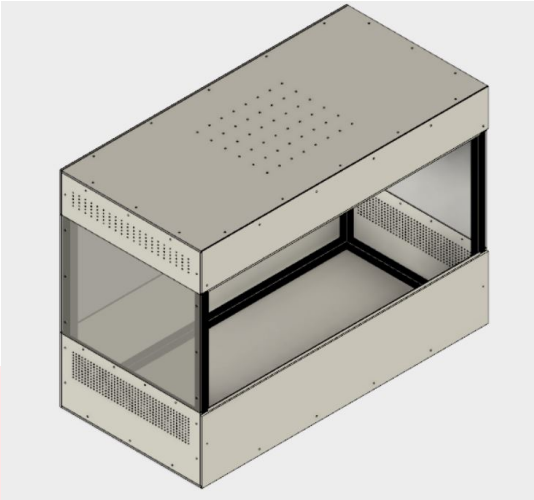
Step 8

Similarly attach the top panels of front, rear and sides to the frame using screws.



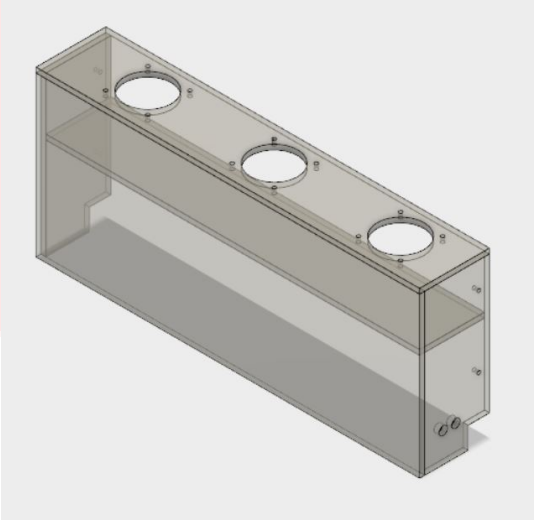
Step 9

Attach the top panel to the frame using screws.



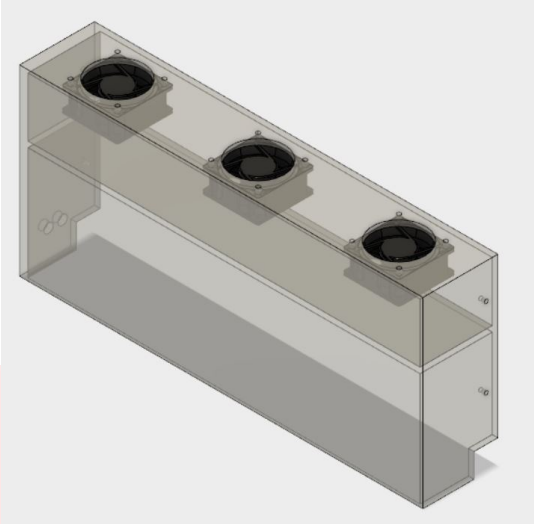
Step 10

Assemble the component box as shown in figure using chloroform.



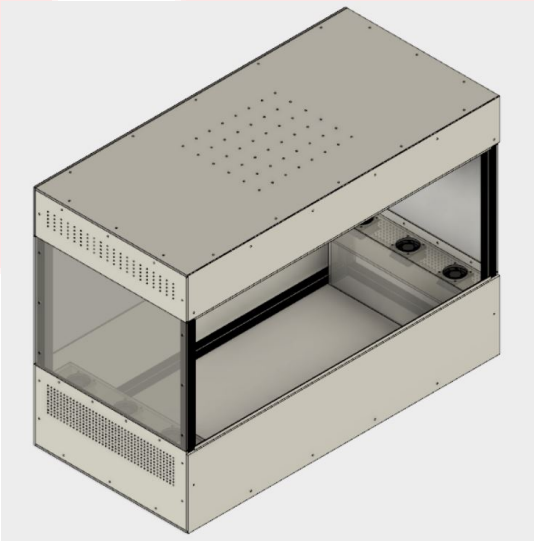
Step 11

Fix the fans to the component box using screws and nuts.



Step 12

Place the component box inside the box as shown in figure and fix them with the help of L brackets and screws.

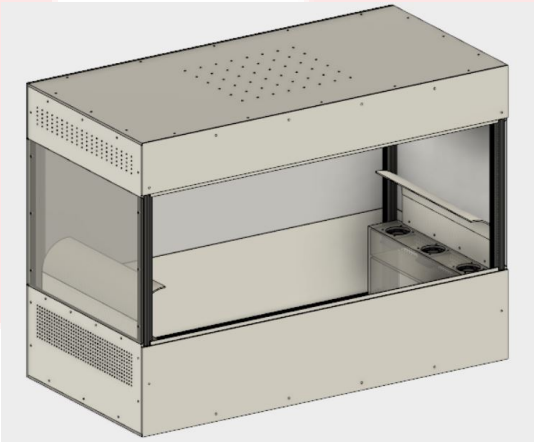


Step 13

Remove the bottom panels of sides and assemble the Electronic components inside the box.

Step 14

Attach the bottom panels of sides and the curve panel using screws.



Step 15

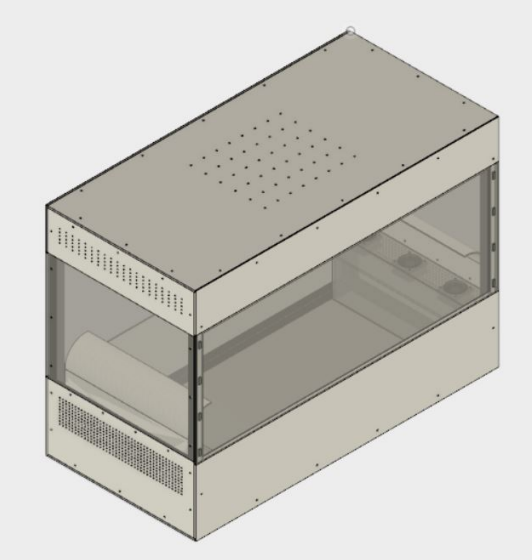
Fix the light holding Aluminum or Mild Iron Strip to the top frame using screws .

Step 16

Fix the sunboard or foam board and magnets on the front side of frame as shown in figure with the help of Fevi Quick and let it cure for some time. Put masking tape above the sunboard and magnets.

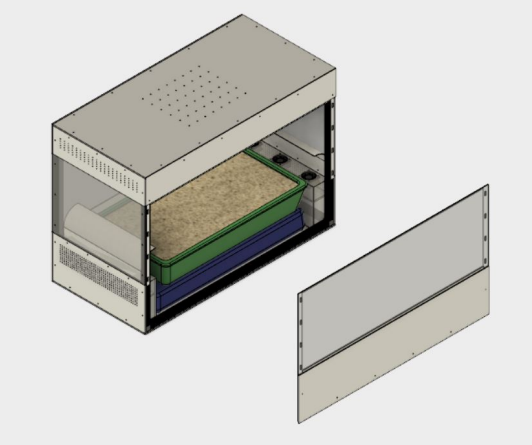
Step 17

Fix the magnets in the grooves provided in front mid panel using Fevi Quick or Araldite and let it cure for sometime. Put masking tape on the magnets. Take care of polarity of the magnets. Now front mid panel can be attached and removed as required.



Step 18

Remove the front mid and bottom panels to pace the Turf inside the Grow Box. Attach the panels back to the frame.



1.4 Design Files

1.4.1 CAD Model Files

- Version1 Models
- Version2 Models

1.4.2 Flow Simulation Files

- Version0
- Version1
- Version2

1.5 Future Work

- Top panel needs to be redesigned in order to allow cooling of LED Flood Light.
- To control temperature, Heater and chiller unit need to be added.
- To control humidity, Humidifier need to be added.
- Carbon filters need to be added at exhaust end to remove any smell from plants.

1.6 Reference

1. Open Agrigulture Website. Farming for Future
2. Autodesk Fusion 360 Website. https://www.autodesk.com/products/fusion-360/featuresdesign
3. Macmaster Carr website. Macmaster Carr
4. Air Circulation Exhaust Tutorial
5. How Air Flow Affects Your Plants
6. SuperCloset Grow Box website

7. BC Northern Lights website
8. 7 Sensors website

1.7 Vendor Links

1. Aluminum Hardware,
2. Square Connectors,
3. Magnets,
4. Axial Flow Fans,