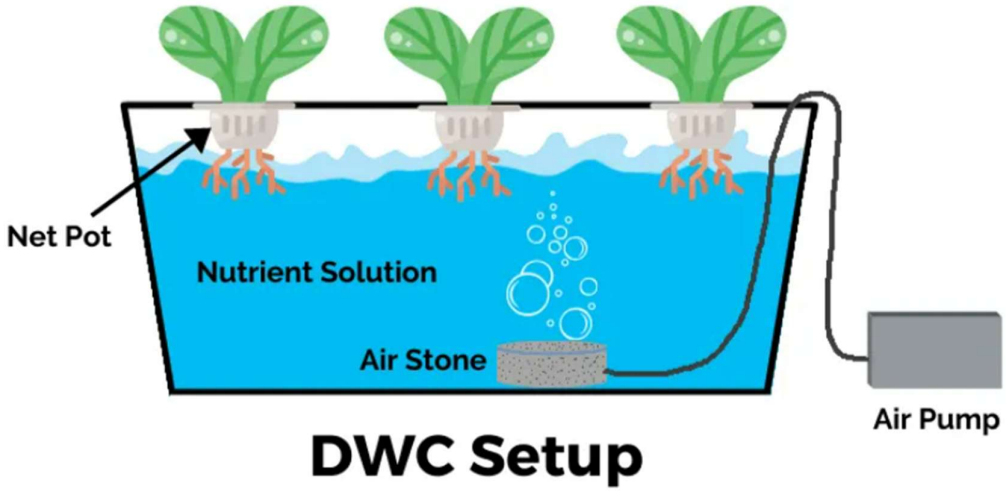
Table of Contents

Graded Assignment Content (Total word counts 2,502)

CHAPTER 1 INTRODUCTION

The purpose of this report is to design a Deep Water Culture (DWC) system that can be used in a small apartment (figure 1).



Source: https://www.seedsandspades.com/dwc-hydroponics-for-beginners/

Figure 1: Deep water culture system

CHAPTER 2 PART RESEARCH AND REFERENCES

The following references are applicable in designing DWC system.

2.1 Platform

The platform is setup above the nutrient reservoir. It is used to support the plants that are grown in the net pots.

2.1.1 Plant spacing

Plant spacing is necessary to ensure the plants are not overcrowded. As this will block the plants from receiving sufficient light. And encourage pathogen infection due to poor air circulation. Based on the plant spacing guideline, a spacing of at least 2.5cm is required (figure 2.1.1).

Vegetable	Spacing Between Plants	Spacing Between Rows
Amaranth	1"-2" (2.5-5 cm.)	1"-2" (2.5-5 cm.)
Lettuce – Leaf	1" – 3" (2.5-7.5 cm.)	1" – 3" (2.5-7.5 cm.)
Mache Greens	2" (5 cm.)	2" (5 cm.)

Source: https://www.gardeningknowhow.com/edible/vegetables/vgen/plant-spacing-chart.htm

Figure 2.1.1: Plant spacing guideline

2.1.2 Net pot

The purpose of a net pot is to support the plant. As such, it has to be used together with growing media (e.g.: LECA balls / rockwool/ cocopeat) to support the plant.

2.1.2.1Existing Product Design

Source: https://a.co/d/gC9yXxv

A) 50mm (inner diameter) net pot dimension

Source: https://a.co/d/0mKPAZz

B) 74 mm (inner diameter) net pot dimension

Source:https://a.co/d/45PModT

C) Bottom centre hole

Source: https://a.co/d/7s3mU8S

D) – Long slot at side

Figure 2.1.2.1: Existing product - net pot design

2.1.3 Cover Storage Stand

The Cover shall be designed to cater for changeable covers with different net pot sizes. As such, a cover storage stand shall also be included. The design is similar to the following existing product (figure 2.1.3).

Source: https://a.co/d/dePwdpW

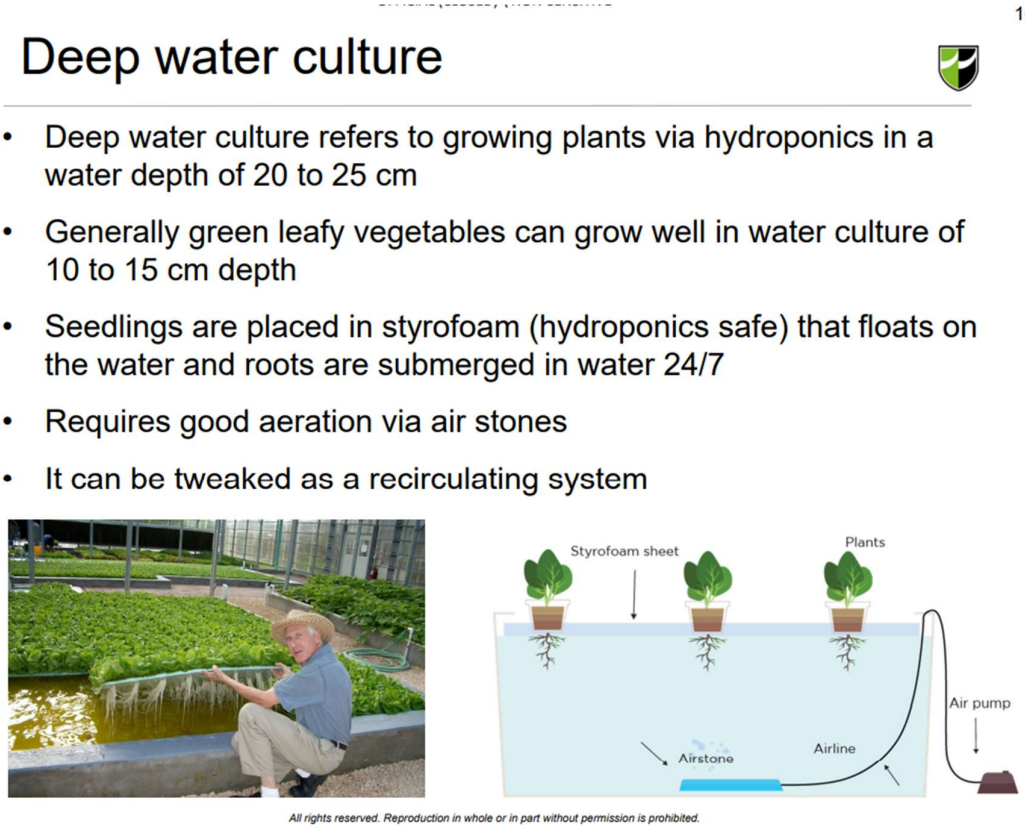
Figure 2.1.3: Existing storage stand design

2.2 Nutrient Reservoir

As this is a hydroponic system, the plants need to uptake nutrients from the nutrient reservoir. The following references are considered in designing the nutrient reservoir's container.

2.2.1 Depth

Generally, the depth shall range from 10 cm to 25 cm (figure 2.2.1).



Source: A2639C Agro-Ecosystem and Farming - Lesson 03 Hydroponics II: Deep water culture

Figure 2.2.1: Recommended depth

2.2.2 Volume

The volume shall range from 2 litres to 10 litres (figure 2.2.2).

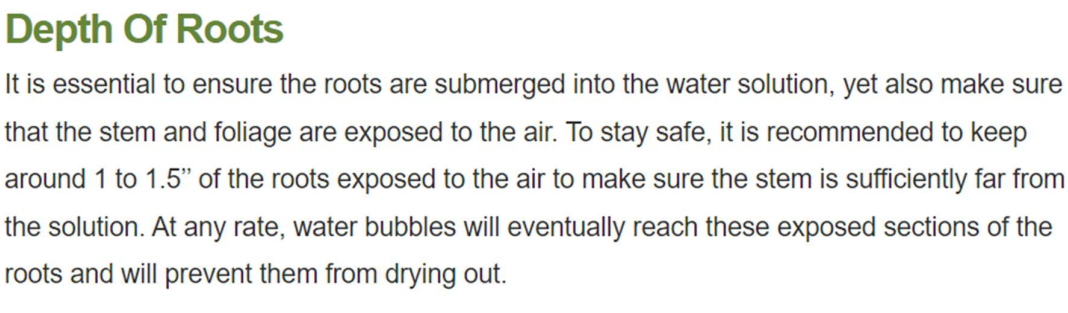
Plants	Min. volume of nutrient solution per plant in the system
Small leafy vegetables, strawberries, lettuce	2 Litres
Herbs or bush varieties of peppers	4-6 Litres
Larger varieties of peppers, melons, cucumber, squash tomato	10 Litres

Source: A2639C Agro-Ecosystem and Farming - Lesson 03 Hydroponics II: Water tubing and reservoir

Figure 2.2.2: Volume guideline of nutrient solution

2.2.3 Roots Spacing

A pocket space of 2.5cm to 3.8cm is recommended between the plant stem/foliage and the surface of the reservoir (figure 2.2.3).



Source: https://smartgardenguide.com/deep-water-culture-hydroponics/

Figure 2.2.3: Recommended roots spacing

2.2.4 Existing DWC Product Design

Source: https://ezbuy.sg/product/51000490737020.html?ezspm=1.20000000.22.0.3

Figure 2.2.4: Existing product – DWC system

2.2.5 Collapsible Product Design

The container height is adjustable. Hence, a collapsible panel shall be included. As there is no existing DWC product, it shall adopt a similar concept as shown in figure 2.2.5.

Source: https://www.thebabyfootprint.com/Stojo-Collapsible-Water-Bottle_p_4388.html

Source: https://www.caravanaccessoryshop.co.uk/product/collapsible-water-container-10ltr/211

Figure 2.2.5: Collapsible product

2.3 Aeration

Water aeration is necessary to prevent pathogen and better root growth. Commonly, an air pump and air stone shall be used.

2.3.1 Existing Product Design

2.3.1.1 Air Stone

A) Spherical

Source:

https://www.amazon.com/dp/B06XGDWP9C/ref=emc_b_5_t

B) Cylinder

Source:

https://www.amazon.com/dp/B076RZBLGS/ref=emc_b_5_t

Figure 2.3.1: Existing product – air stone

2.3.1.2 Air Pump

Source: https://a.co/d/9Wivk7W

Figure 2.3.1.2: Existing product - air pump

CHAPTER 3 DESIGN CONSIDERATION

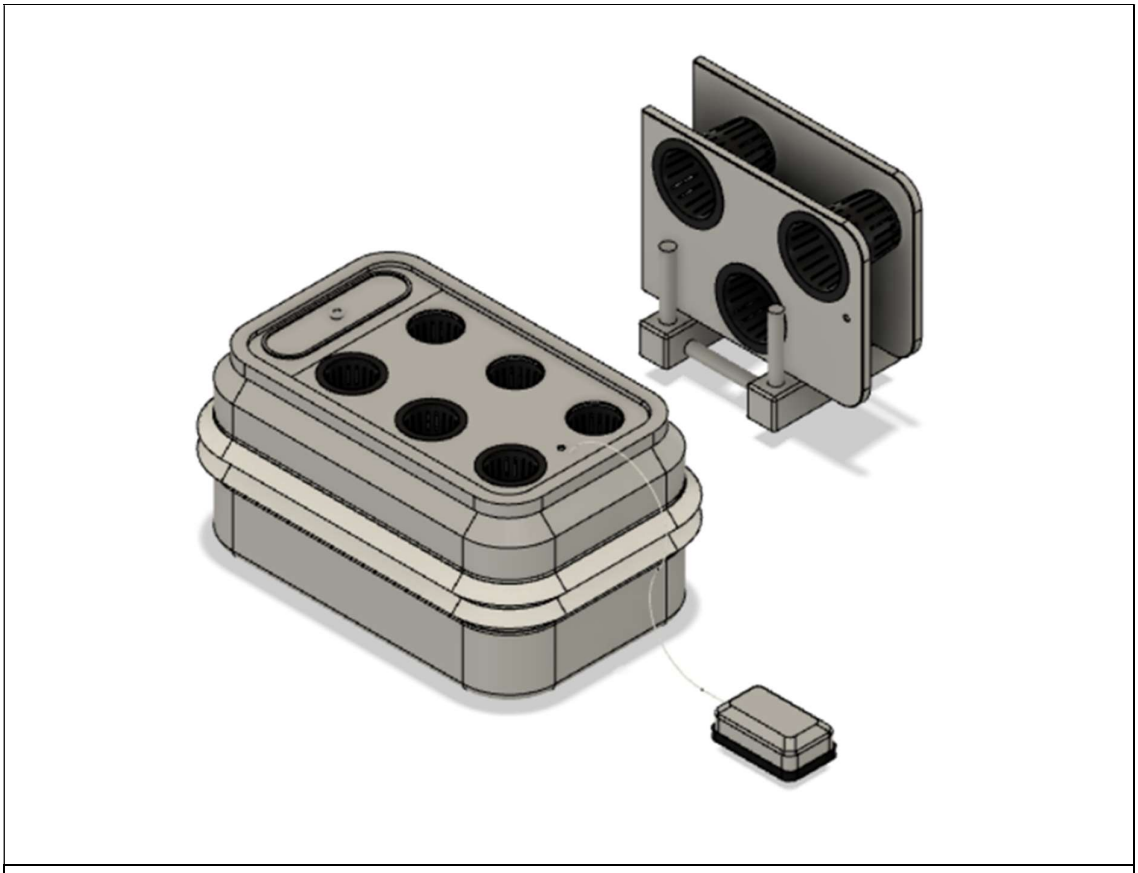


Figure 3: DWC System

The DWC system design consideration:

- To grow a maximum of 6 plants
    - Which is manageable and does not require frequent nutrient solution refill
- A rectangular container with cover shall be designed
    - Container – nutrient reservoir
    - Cover - platform to grow plants
- Air pump and air stone are used to aerate the nutrient reservoir

Besides, the DWC system shall also consist of the following features:

- Container to include
    - Collapsible panel
    - Pocket space
    - Anti-slip bottom
- Cover to include
    - An open & close panel
    - Changeable net pots' covers
- Changeable cover storage stand

In Fusion, the DWC is assembled with various Components and Bodies (figure 3)

3.1 Cover

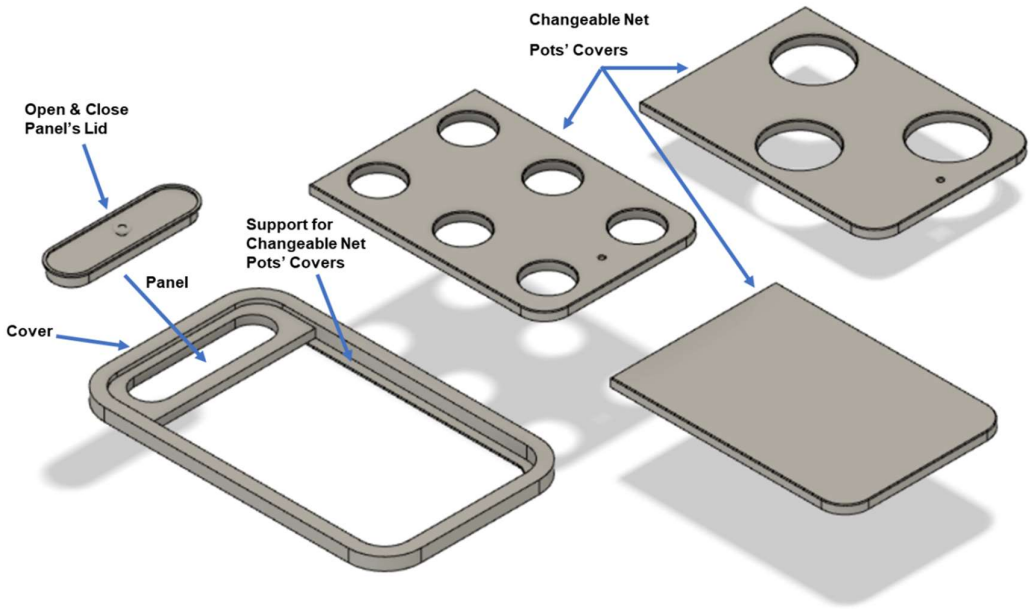


Figure 3.1: Cover components

3.1.1 Open & Close Panel

3.1.1.1 Purpose

A panel with lid is included to:

- Reduce the number of times of lifting the platform's cover:
  - Prevent the plants' roots from being clamped in between the cover and container
  - Prevent the repositioning of the air tube
  - Provide a hassle-free handling when measuring the reservoir conditions, such as the following handling is cumbersome
    - one hand is used to tilt and support the platform/cover
    - the other hand is used to hold the measuring tool (e.g.: pH device or Electrical Conductivity device) and ensuring it will not drop into the reservoir

3.1.2 Changeable Net Pots' Covers

3.1.2.1 Purpose

To cater for different sizes of net pot, changeable covers shall enable:

- More plant selections (e.g.: herbs, leafy vegetables, tomatoes and etc.)
- Right net pot size and right plant spacing (section 2.1.1)
    - to support the plant growth
    - prevent plant from tumbling / tilting when it grows bigger

3.1.3 Design Consideration

3.1.3.1 Open & Close Panel

To provide a bigger window view, it is designed along the edge of the Cover. As this panel will be open & close frequently, a lid with a round knob is designed for easy grabbing.

3.1.3.2 Changeable Net Pots' Covers

Three changeable covers shall be designed for home grower to select. That are:

- Plain cover with no holes for customise purpose
- Three holes (70 mm) with three net pots and an air tube hole
- Six holes (50 mm) with six net pots and an air tube hole

3.1.3.3 Fusion Design Consideration

For the Cover,

- Sketch rectangle and fillet
    - Create Offset to create smaller / bigger similar shapes
    - Sketch the Open & Close Panel and Net Pot's Cover
- Use Extrude to create the Cover Body and Open & Close Panel Body

For the Open & Close Panel,

- Sketch a rectangle with fillet for the cover and circle for the knob
- Use Extrude and Torus to create the Lid and Knob

For the Changeable Net Pots' Cover

- Create the support on the Cover
    - Sketch a rectangle on a Projected dot
    - Use Sweep to create the Support
        - Chamfer the Support

- For the Plain Net Pots' Covers
    - Use Extrude to create Plain Cover Body
    - Move the Body

- For the 6 Net Pots' Cover or 3 Net Pots' Cover
    - Copy a new Plain Net Pot's Cover Body
    - Move the Cover
    - Create sketch on the Top View
        - Net pots' holes
            - Create circle and duplicate it using Rectangular Pattern
        - Air tube hole
            - Create circle and centre it to the Cover

- Convert the Bodies into Components
- Assemble the Components

3.2 Changeable Cover Storage Stand

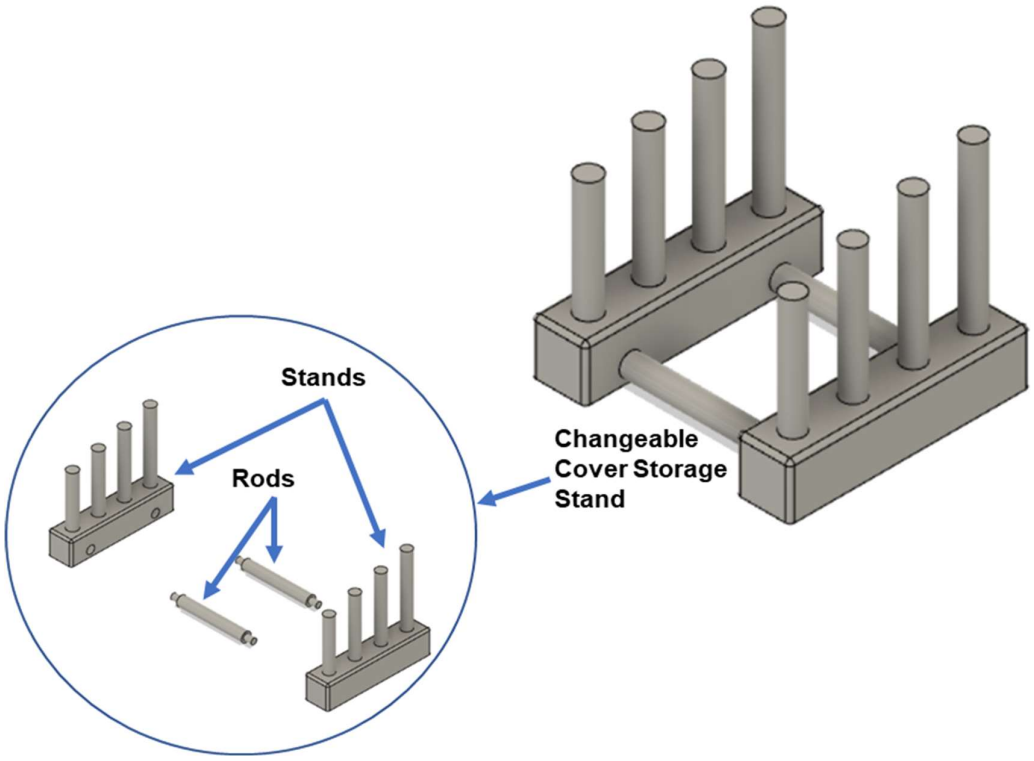


Figure 3.1.3: Changeable cover storage stand

3.2.1 Purpose

To store the changeable net pots' covers.

3.2.2 Design Consideration

In Fusion,

- For the stand
    - Sketch a square and followed by Extrude to create the 1st Stand Body
    - On the Top view, create a circle and duplicate 3 additional circle using Rectangular Pattern
    - On the Side view, create a circle for the rod and mirror it to create another circle
        - Create two holes on the stand
        - Create the Rods' Bodies by using the Extrude, Copy/Move and Offset
    - Create a copy of the stand for the 2nd Stand Body
        - Fillet the edges
        - On the Top view, use Extrude to create the 4 round supports on each stand

- Convert the Bodies into Components
- Assemble the Components

3.3 Net Pots

Figure 3.3: Net pot sizes

3.3.1 Purpose

To cater for different net pots sizes and there shall be:

- Two sizes (i.e.: 50mm and 70mm)
- Black net pot helps to prevent algae growth
- A flat and wide lip for easy grabbing
- Slotted mesh instead of a few long slots at the side
    - Allow more choices of growing media (LECA, Pumice and etc.)
- Bottom shall consist of a centre hole to
    - guide roots development
    - direct roots down to the reservoir and encourage faster growth

3.3.2 Design Consideration

In Fusion,

- For the net pot size
    - Sketch lines to state the size (i.e.: length, width and height)
        - Use Offset to create the net pot shape
        - Create the slotted mesh by drawing a rectangle
            - Use Rectangular Pattern to duplicate the rectangle
    - Use Revolve to create the Net Pot Body
    - Use Extrude and Circular Pattern to create the side of the net pot

- For the bottom of the net pot,
    - Sketch circle and create more circles using Offset
        - Draw a triangle that will be used to create holes
    - Use Revolve, Extrude, Circular Pattern to create mesh and holes

3.4 Container

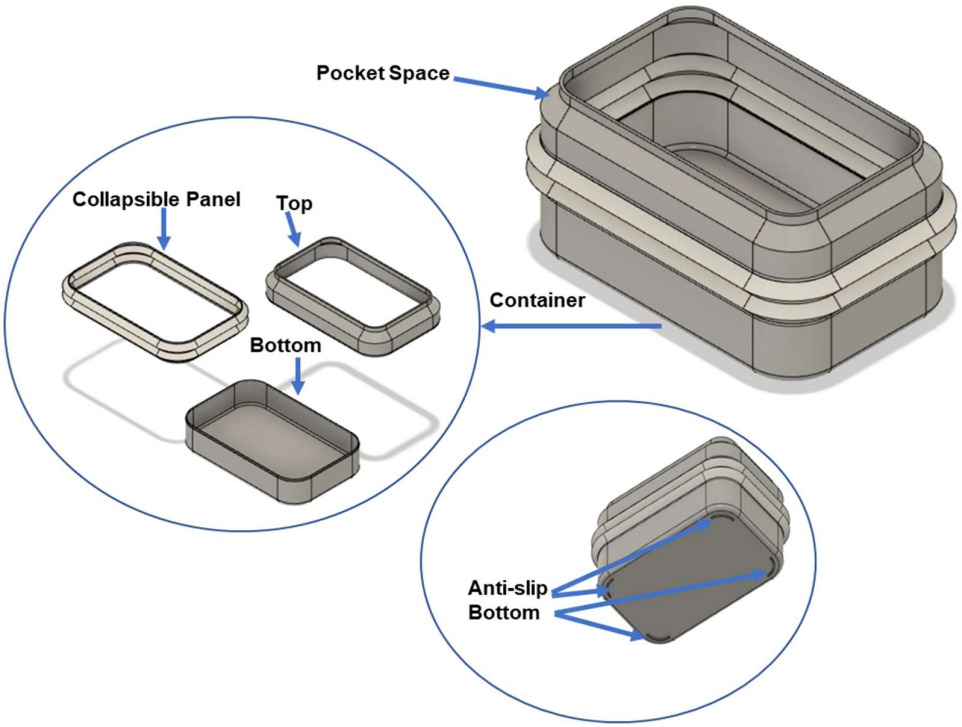


Figure 3.4: Container

3.4.1 Collapsible Panel

3.4.1.1 Purpose

The Container is collapsible and enables:

- Home grower to adjust the container according to the right volume of solutions for the right plants at the right time
- Using the same container for light feeder (e.g.: lettuces) and heavy feeder (e.g.: tomatoes) plants
- Able to transplant the seedlings at an earlier stage after success germination
    - By adjusting the container to the desired height
- Easy maintenance as it prevents the following issues:

- During hot weather, the reservoir evaporates more than what the plants required
    - create salts residues around the container while the plants are growing and ready for harvesting
        - may require more frequent changing and washing of the container
    - requires frequent nutrient solution replenishment

- Right amount of nutrient solution at the right time
    - At different growing stage, the plant uptakes different amount of nutrient solution
        - Seedling stage - plant absorbs less volume of nutrient solution as compared to vegetative stage
        - Flowering stage - plant needs more volume of nutrient solution than in vegetative stage

3.4.2 Pocket Space

3.4.2.1 Purpose

The container Pocket Space is included to enable:

- Root spacing (section 2.2.3)
- Anti-spillage
    - A slope is designed to prevent water spillage
        - Withstand shake when there is water movement (e.g.: accidentally knock or moving container from one location to another)

3.4.3 Anti-slip Bottom

3.3.3.1 Purpose

The raised base is included to enable:

- Anti-slip to prevent the container from moving
- Anti-wear to prevent friction that will wear-off the base of the container

3.4.4 Design Consideration

In Fusion,

- Create the Container
    - On top view,
        - Sketch the container using rectangle and fillet
        - Create Offset to create smaller / bigger similar shapes
        - Create Offset to include guideline of the Cover
            - Ensure right fixing when assemble
    - Use Extrude to create the Container Body
    - Shell the container
    - Fillet the edges

- Create the Anti-slip Bottom
    - On the bottom view,
        - Sketch the base using Offset, Cut and Mirror
        - Use Extrude to raise the 4 bases

- Create the Pocket Space and Top of the Container
    - Construct an Offset Plane
    - Sketch the surface of the Container
    - Use Loft to create the slope and create the Top Container Body
        - Use Extrude to create the surface of the Container
        - Use Loft to cut the inner of the Container

- Create the Collapsible Panel
  - Construct an Offset Plane
  - Split the Container
  - Move the Top of the Container
  - Construct Plane through two edges
  - Create the collapsible folds
    - Sketch a Projected line
      - Draw rectangles to create the top & bottom edges
      - Creating triangle and duplicate it using Rectangular Pattern
    - Use Sweep to create the Collapsible Panel Body by selecting the triangles
      - Shell the panel
    - Use Sweep to create the top & bottom edges by selecting the rectangles
  - Create top/bottom edges of the Container by
    - Sketching Offset
    - Extrude the edges
- Convert the Bodies into Components
- Assemble the Components

3.5 Aeration

3.5.1 Air Stone & Air Tube

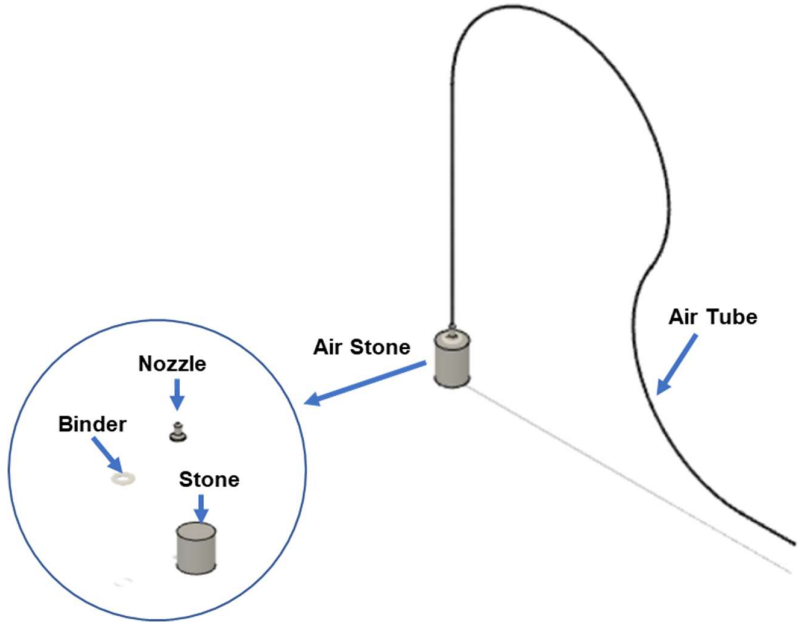


Figure 3.3.1: Air stone & air tube

3.5.1.1 Purpose

A cylinder air stone shall be designed for the DWC system. As it generates more air bubbles as compared to spherical air stone (figure 3.5.1).

The air tube is required to connect the air pump and air stone.

As per my experience, the cylindrical air stones produces more air bubbles compared to rounded shaped ones.

Source: https://roadtobiofloc.com/air-tube-air-stone-for-biofloc-tank/

Figure 3.5.1.1: Cylinder vs spherical air stone

3.5.1.2 Design Consideration

In Fusion,

- For Air Stone
    - Sketch rectangles on the Front view
    - Use Revolve to create the Stone Body and Nozzle Body
    - Fillet the Nozzle

- For Air Tube
    - Sketch lines and curve on the Front view
    - Use Sweep to create the Air Tube Body

- For Binder
    - Create a Torus Body

- Convert the Bodies into Components
- Assemble the Components

3.5.2 Air Pump

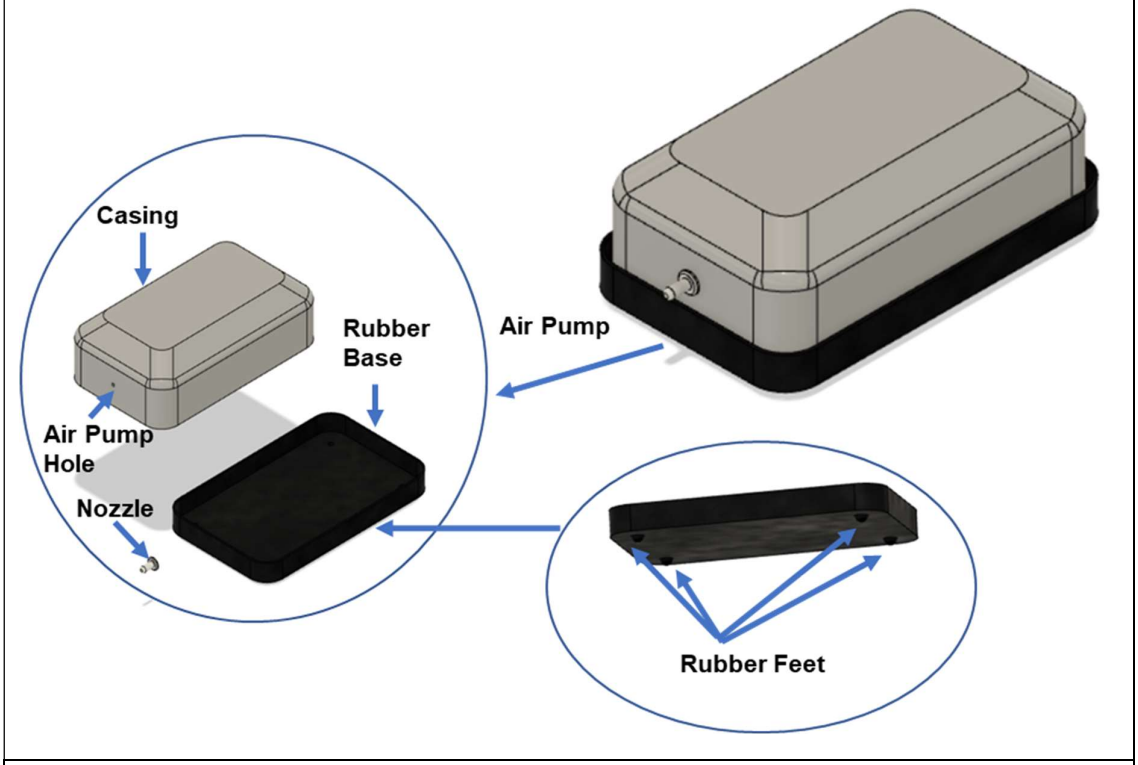


Figure 3.5.2: Air pump

3.5.2.1 Purpose

The Air Pump shall be designed to include:

- Single outlet on the casing
- Rubber base with rubber feet to absorb vibration and reduce noise

3.5.2.2 Design Consideration

In Fusion,

- For Nozzle
    - Sketch circles
    - Using Extrude to create the Body
    - Fillet the top and Chamfer the base

- For Casing and Rubber Base
    - Sketch rectangles
    - Using Extrude to create the Bodies
    - Chamfer and Fillet the Casing
    - Shell the Bodies
    - Sketch a circle on the front of the casing
        - Using Extrude to cut a hole to create air pump hole

- For Rubber Feet
    - Sketch a circle
    - Using Revolve to create a rubber foot
    - Mirror the rubber foots to all corners

- Convert the Bodies into Components
- Assemble the Components

CHAPTER 4 REFLECTION

4.1 Learning Curve of using Fusion 360

This is a useful software and during the learning process, these are my opinions:

- Easy to use even with steep learning curve
    - Need to remember and understand the user interface and navigation (e.g.: Application bar, Toolbar, ViewCube, Browser, Marking Menu, Timeline and Navigation)
    - Which orthographical projection to use to sketch the design (Top / Front / Side)
    - How to use the origin planes / construction planes / flat model face to create 2D sketches
    - In 2D sketch,
        - how to create an object using the line/rectangular/circle/slots and etc.
        - how to use the constraints and dimensions to fully define object into a solid line (i.e.: change a circle from blue line to black line)
    - In 3D sketch,
        - How to use the 3D modelling features (e.g.: Extrude. Revolve and etc) to model the sketch
- Perform many times of redrawing to streamline the design timeline
- Using the Section Analysis to inspect the components are assembled perfectly
    - Fitting the components and adjusting the measurements become tricky when the actual measurements of the parts are slightly off
- Since this is a cloud software, a high-speed internet connection is required
- It utilizes large amount of disk space, computer processor (CPU) and memory (RAM) of my computer
    - Computer lagging and slowness may happen occasionally

4.2 Designing & Prototyping

In the DWC system design, some functional improvements have been made on the Cover and Container. As there are no existing DWC product, I need to research, plan and design the components.

Hence, most of the times are spent on experiencing the right sketches to draw and right modelling features to use.

Besides, I am not sure whether:

- The designs are practical for 3D printing
- When the product is actually made, how to carry out prototyping to ensure:
    - All the components can assemble perfectly
    - The Cover can support the weight of the full-grown plants
    - Container
        - Collapsible panel will not cause water leakage
        - Pocket space is able to withstand water spillage

APPENDIX

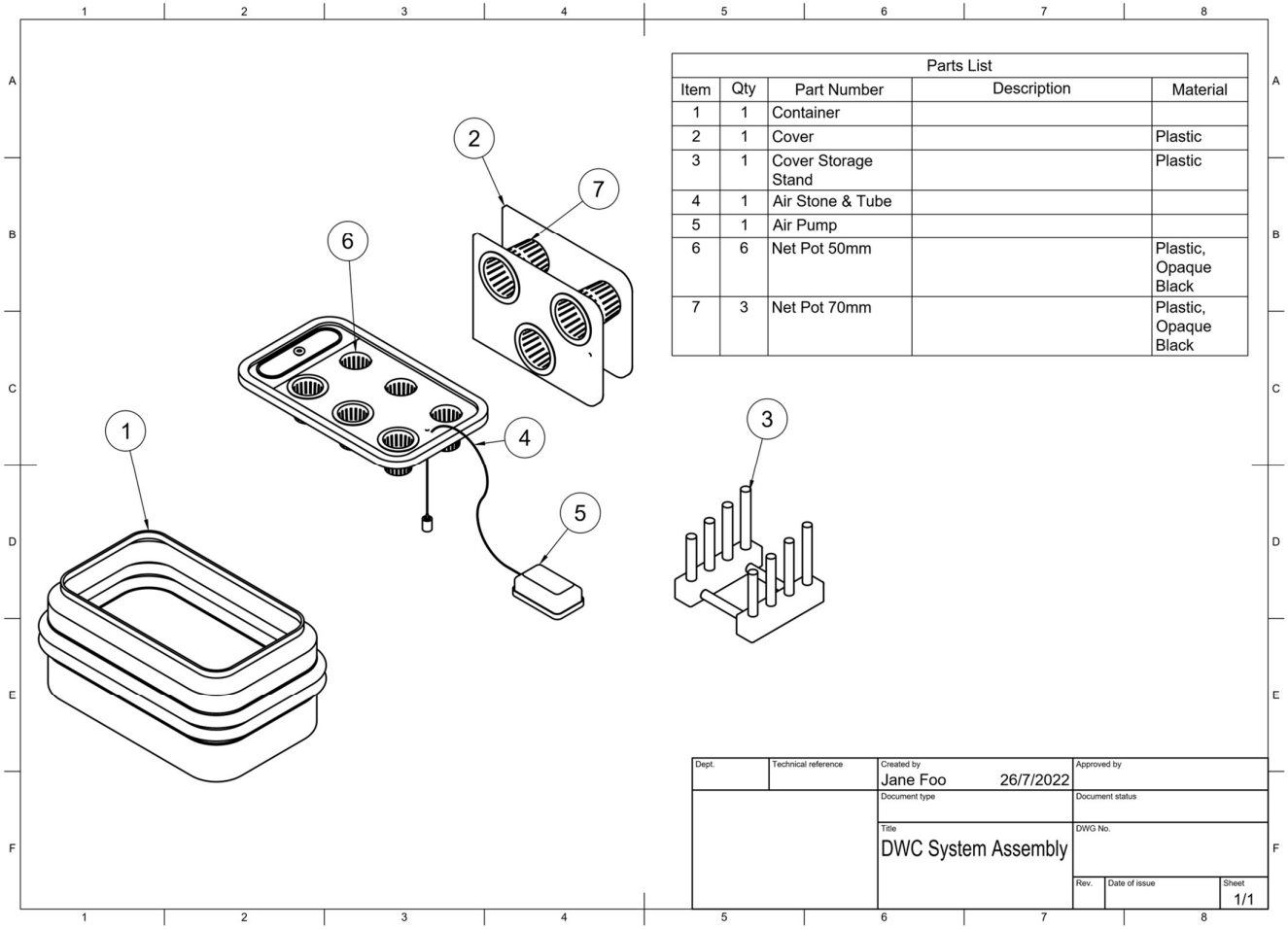
A1 Fusion 360 References

Sno.	Description	Fusion References
1	DWC System	• DWC System Assembly BOM • DWC System Assembly Drawing
2	Cover	• Cover BOM • Cover Drawing
3	Net Pots	• Net Pot 50mm Drawing • Net Pot 70mm Drawing
4	Changeable Cover Storage Stand	• Cover Storage Stand BOM • Cover Storage Stand Drawing
5	Container	• Container BOM • Container Drawing
6	Air Stone & Air Tube	• Air Stone & Tube BOM • Air Stone & Tube Drawing
7	Air Pump	• Air Pump BOM • Air Pump Drawing

A2 DWC System

A2.1 Assembly

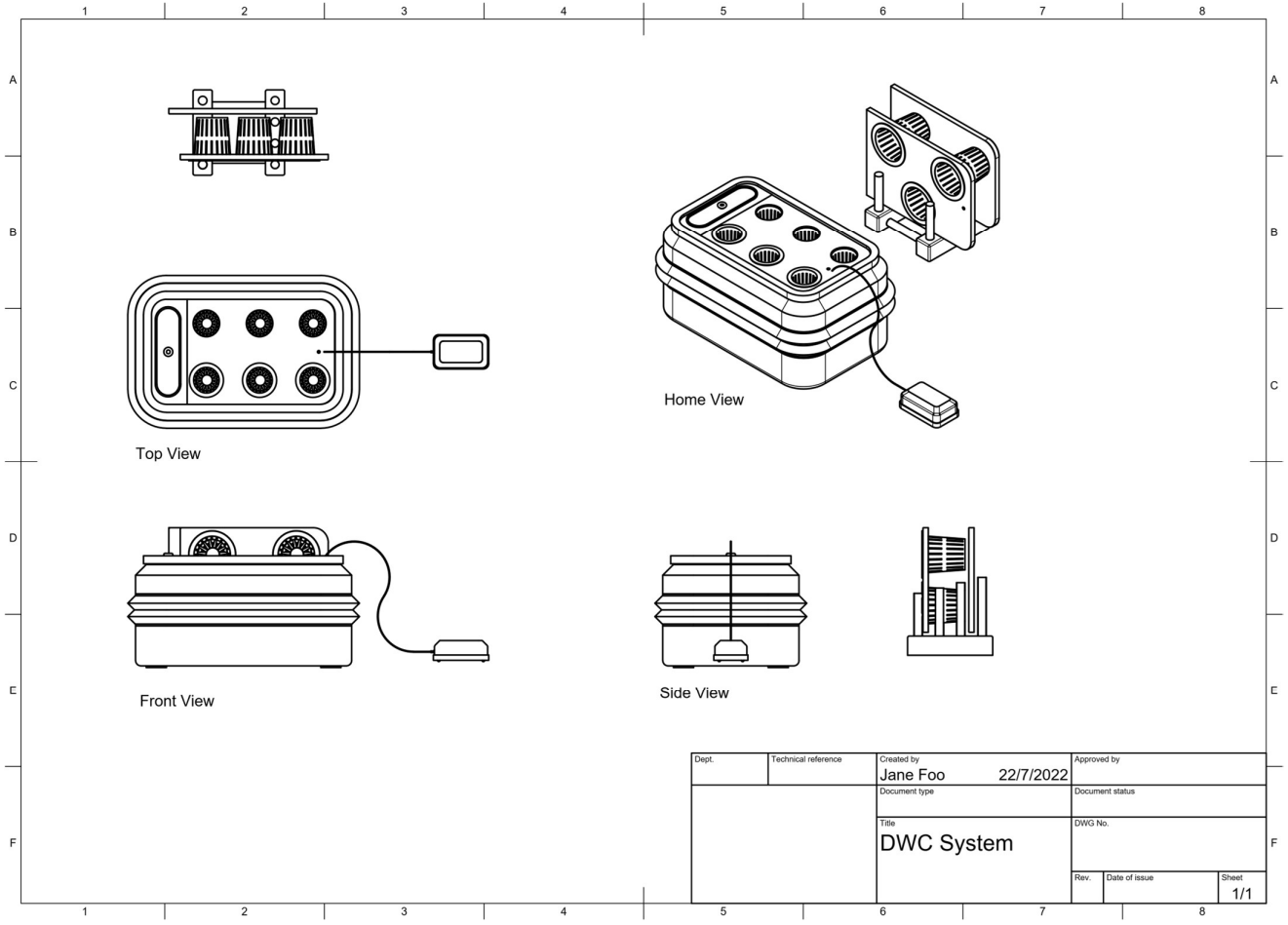
A2.1.1 BOM



Parts List				
Item	Qty	Part Number	Description	Material
1	1	Container		
2	1	Cover		Plastic
3	1	Cover Storage Stand		Plastic
4	1	Air Stone & Tube		
5	1	Air Pump		
6	6	Net Pot 50mm		Plastic, Opaque Black
7	3	Net Pot 70mm		Plastic, Opaque Black

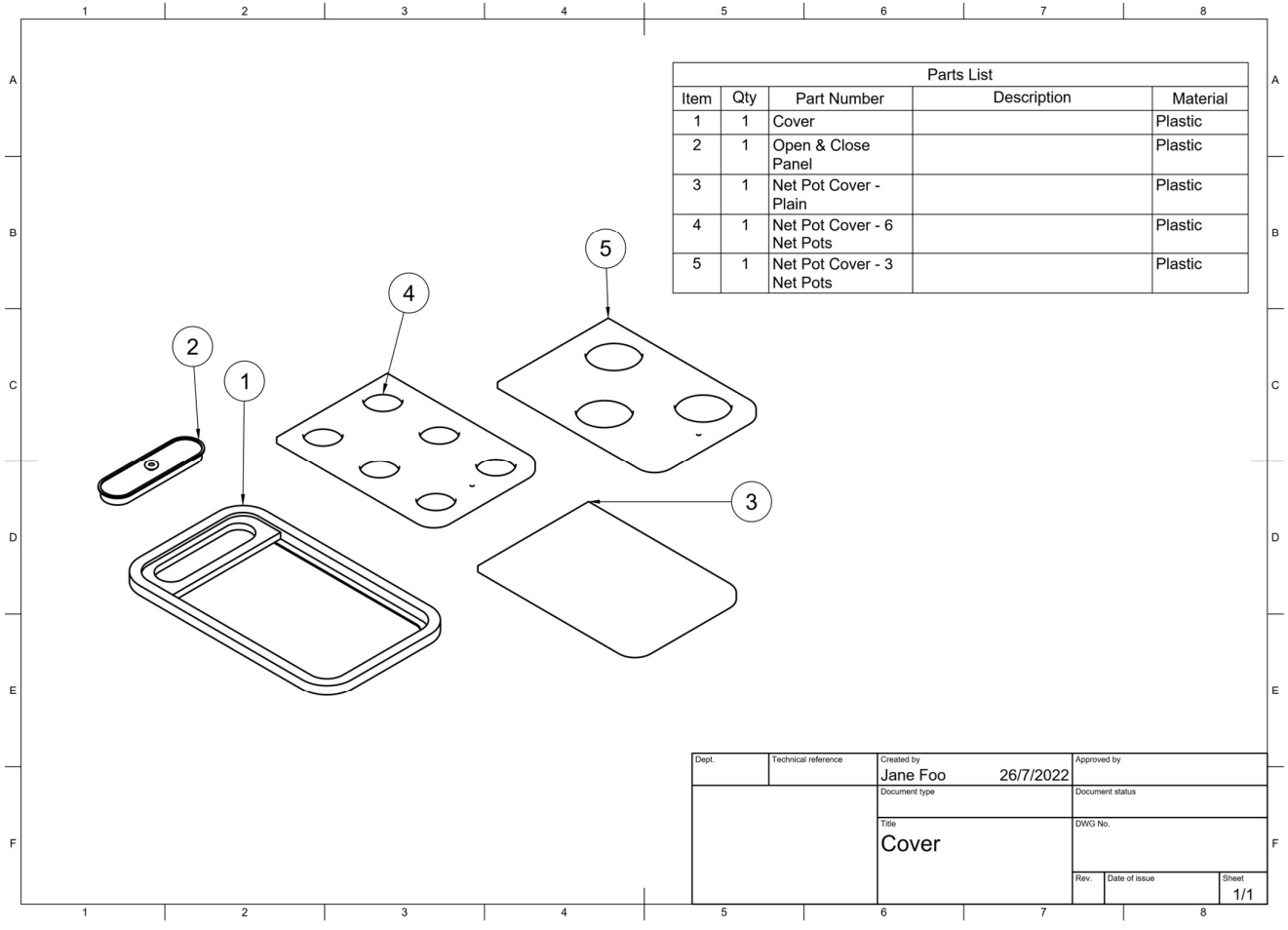
Dept.	Technical reference	Created by: Jane Foo 26/7/2022	Approved by
		Document type	Document status
		Title: DWC System Assembly	DWG No.
			Rev. / Date of issue / Sheet: 1/1

A2.1.2 Drawing

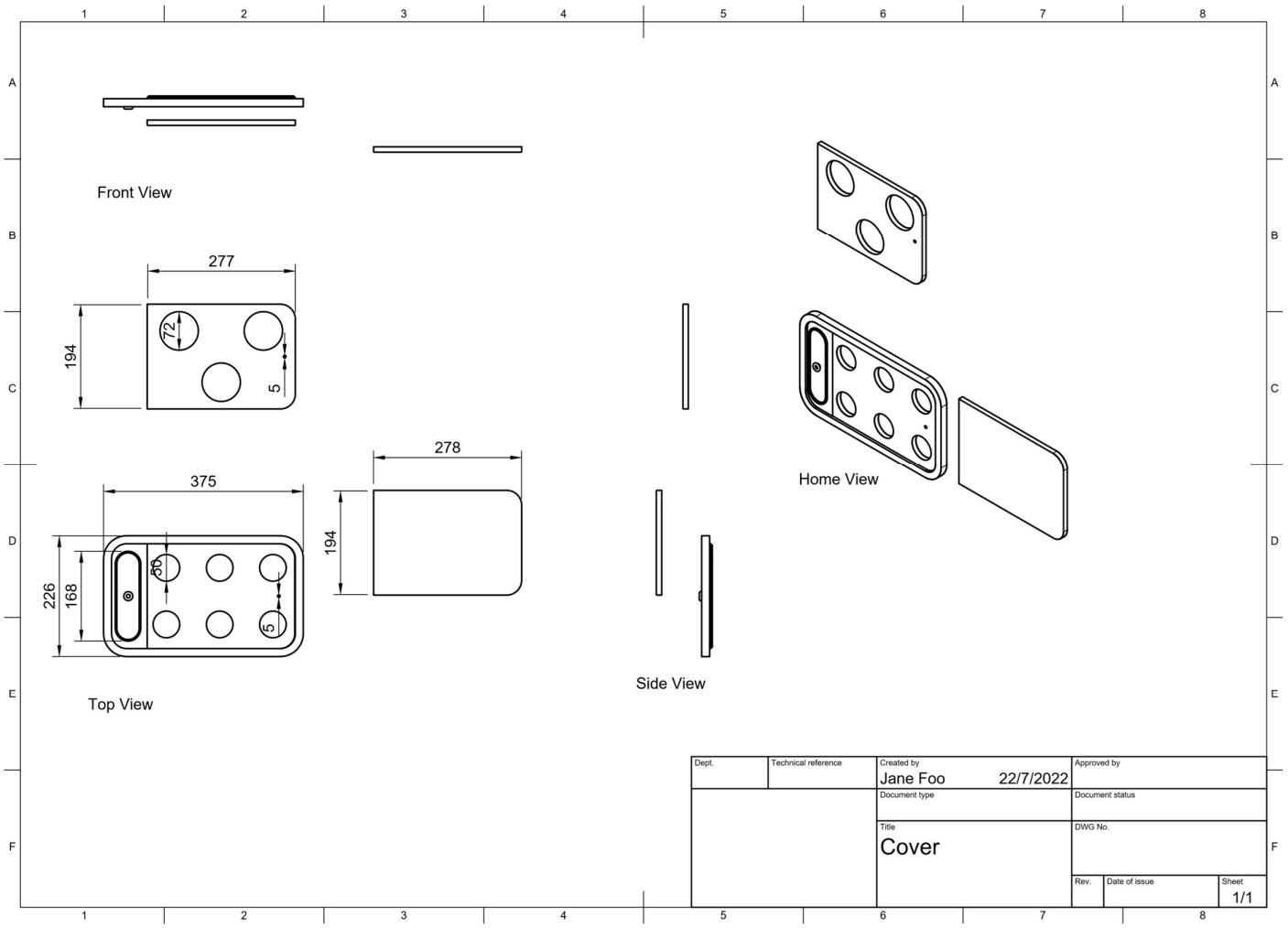


A2.2 Cover

A2.2.1 BOM

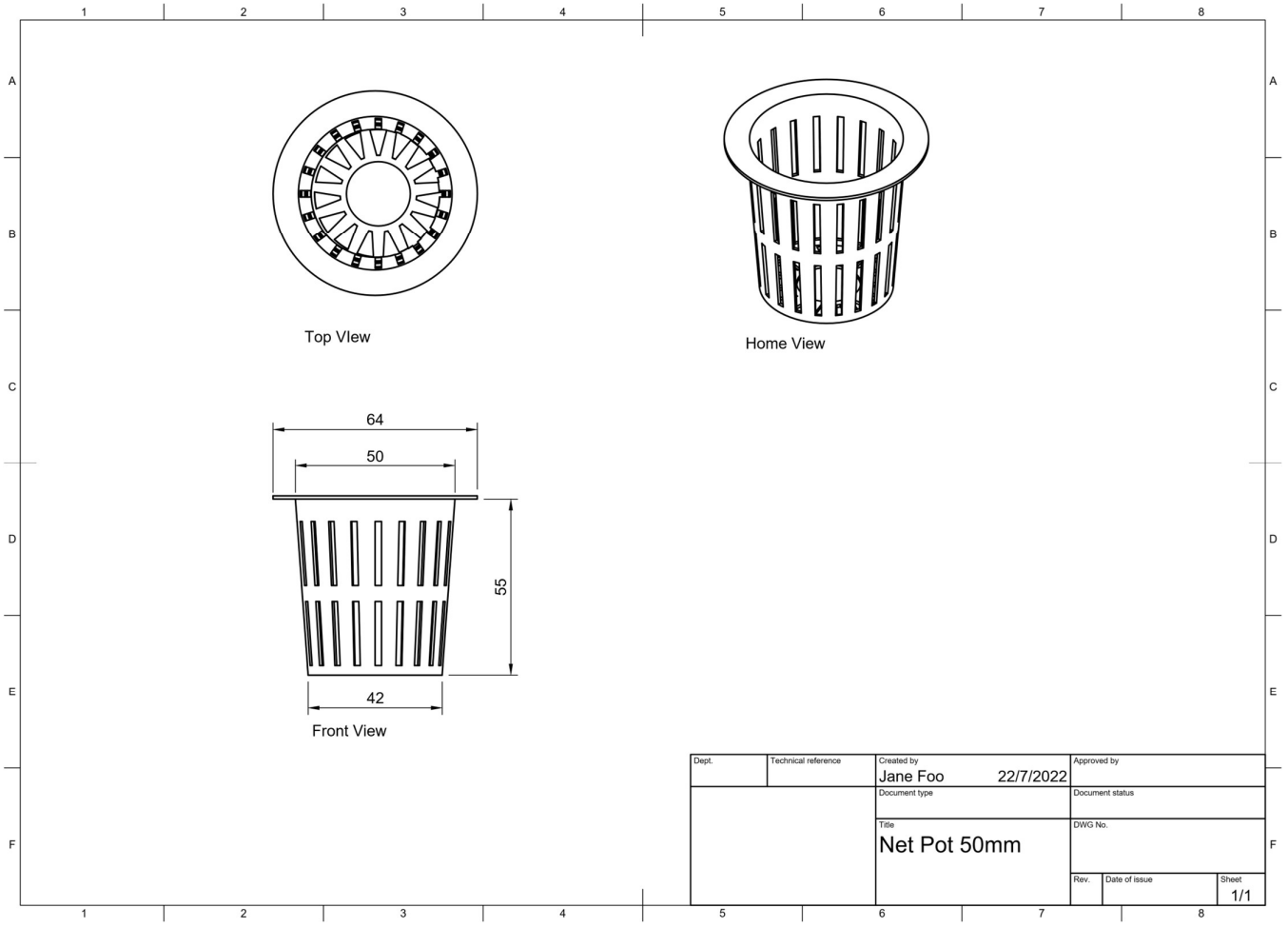


A2.2.2 Drawing

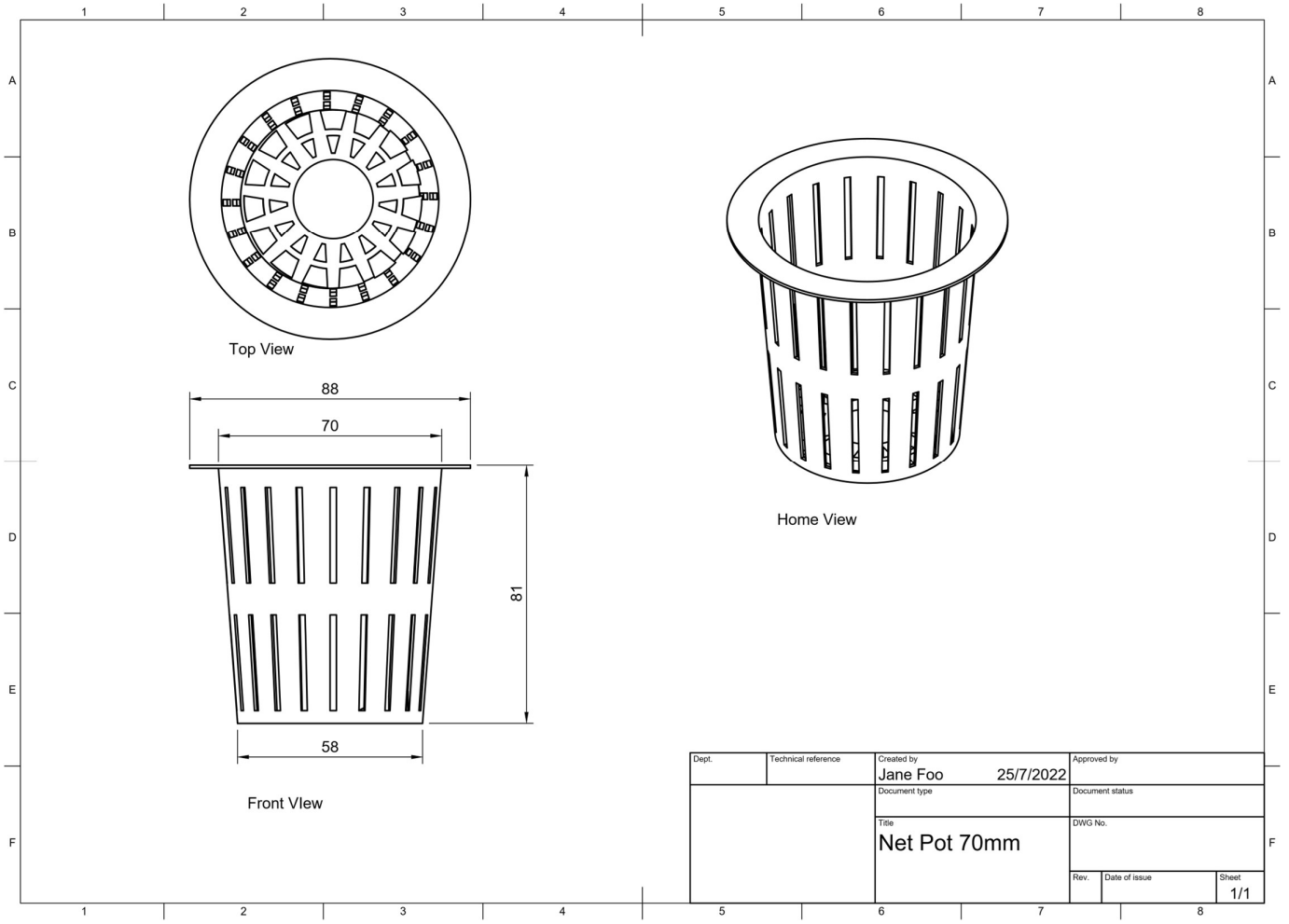


A2.3 Net Pots

A2.3.1 Net Pot 50mm Drawing



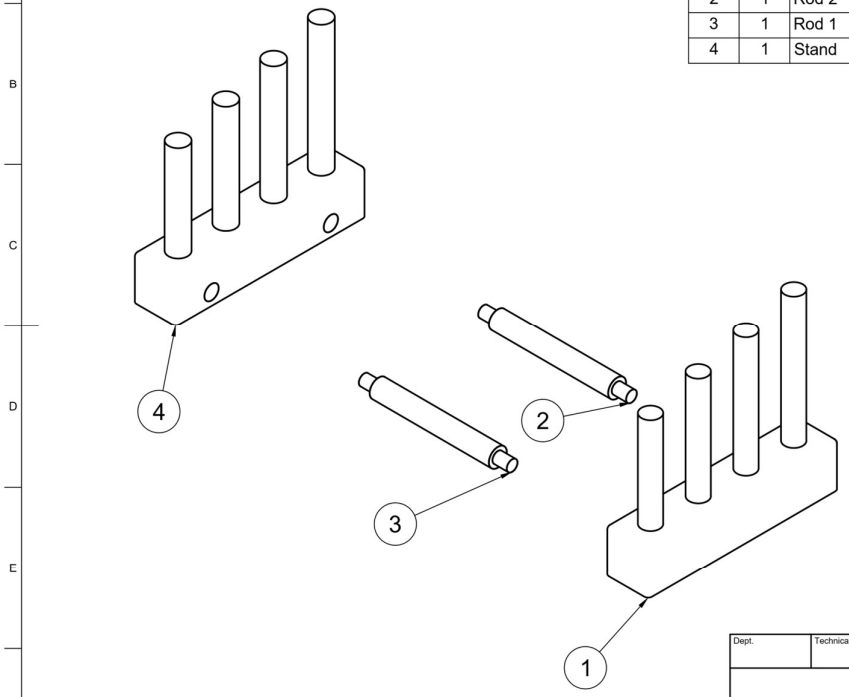
A2.3.2 Net Pot 70mm Drawing



A2.4 Changeable Cover Storage Stand

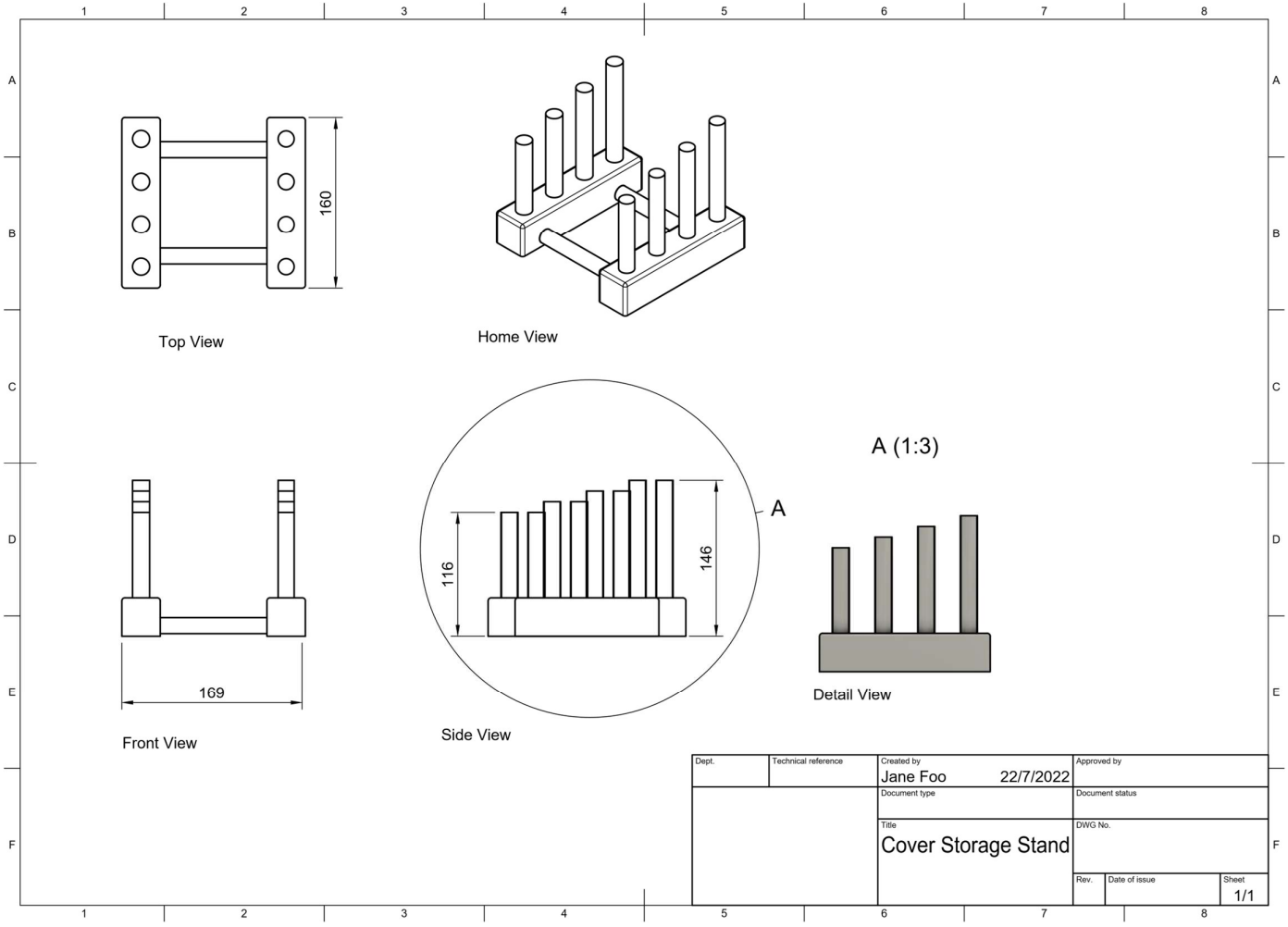
A2.4.1 BOM

Parts List				
Item	Qty	Part Number	Description	Material
1	1	Stand 2		Plastic
2	1	Rod 2		Plastic
3	1	Rod 1		Plastic
4	1	Stand		Plastic



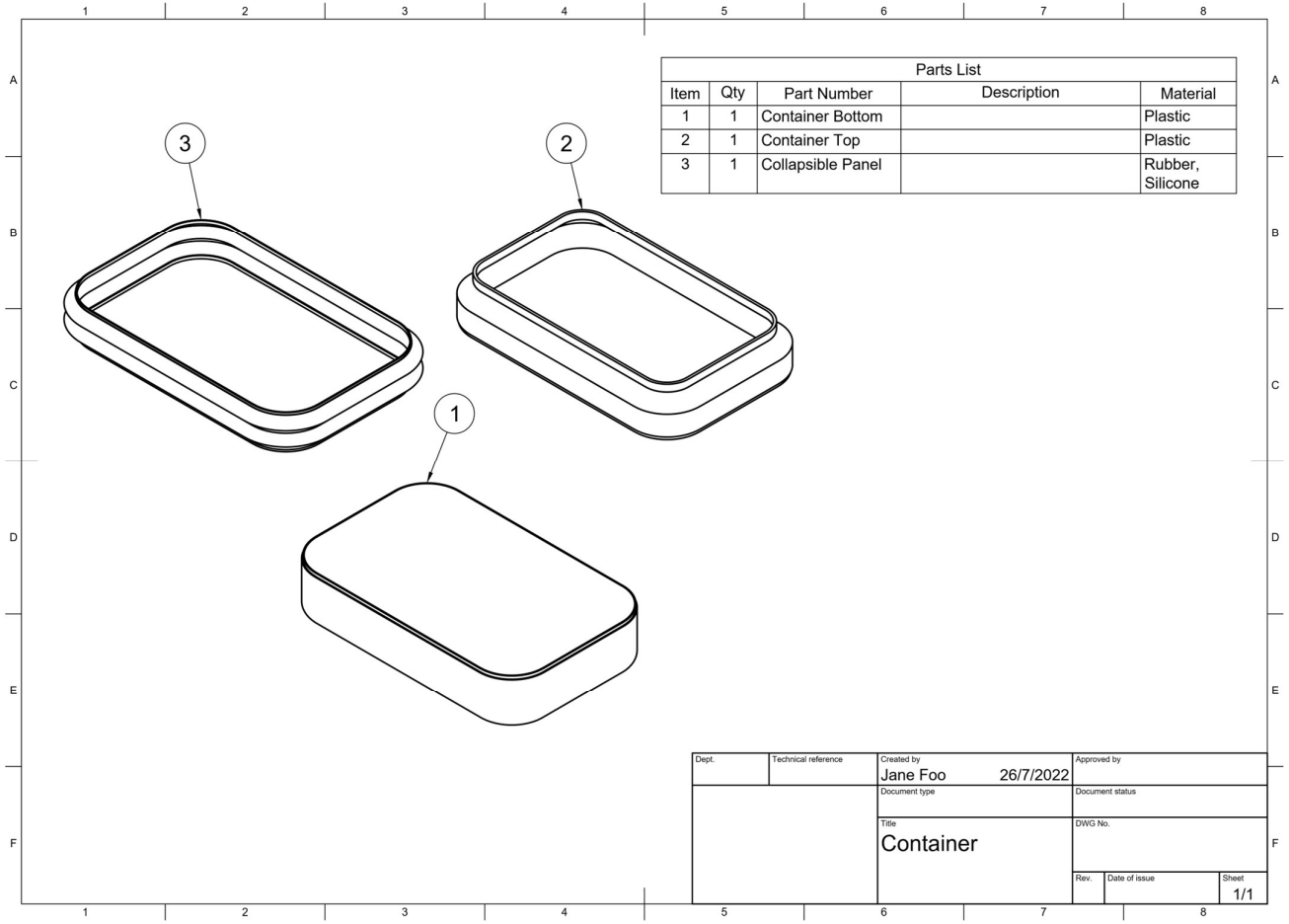
Dept.	Technical reference	Created by: Jane Foo 25/7/2022	Approved by
		Document type	Document status
		Title: Cover Storage Stand	DWG No.
		Rev. / Date of issue	Sheet: 1/1

A2.4.2 Drawing

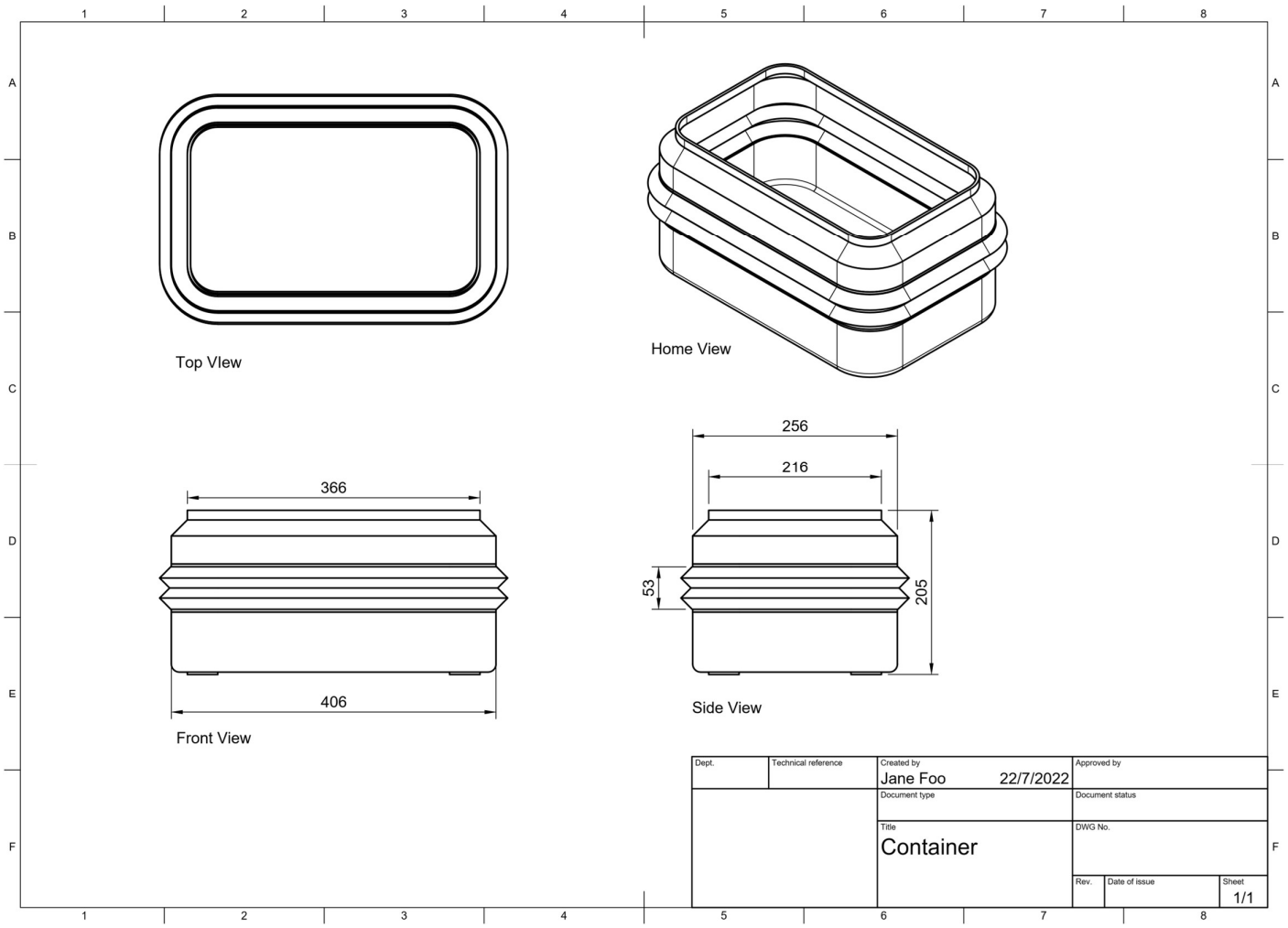


A2.5 Container

A2.5.1 BOM

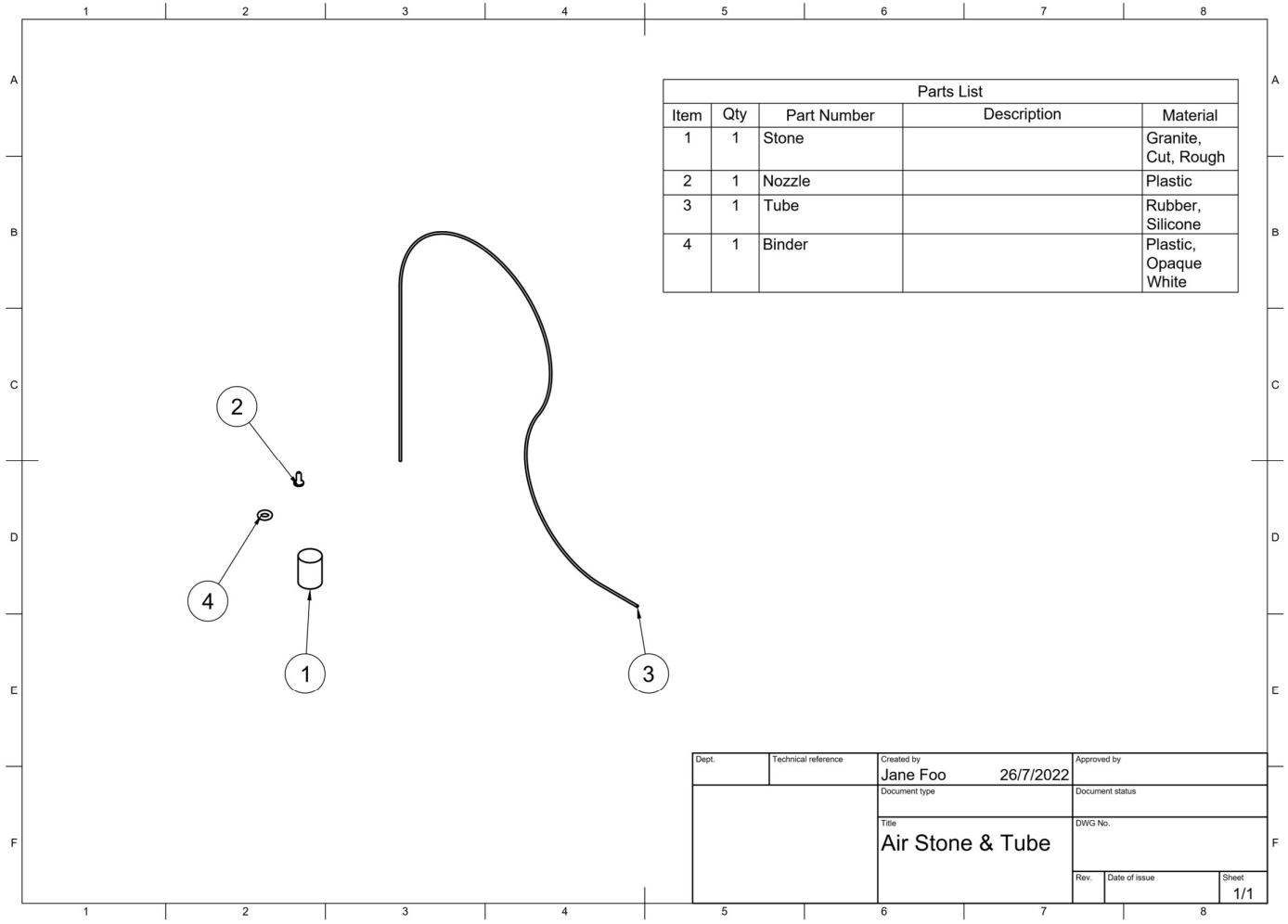


A2.5.2 Drawing

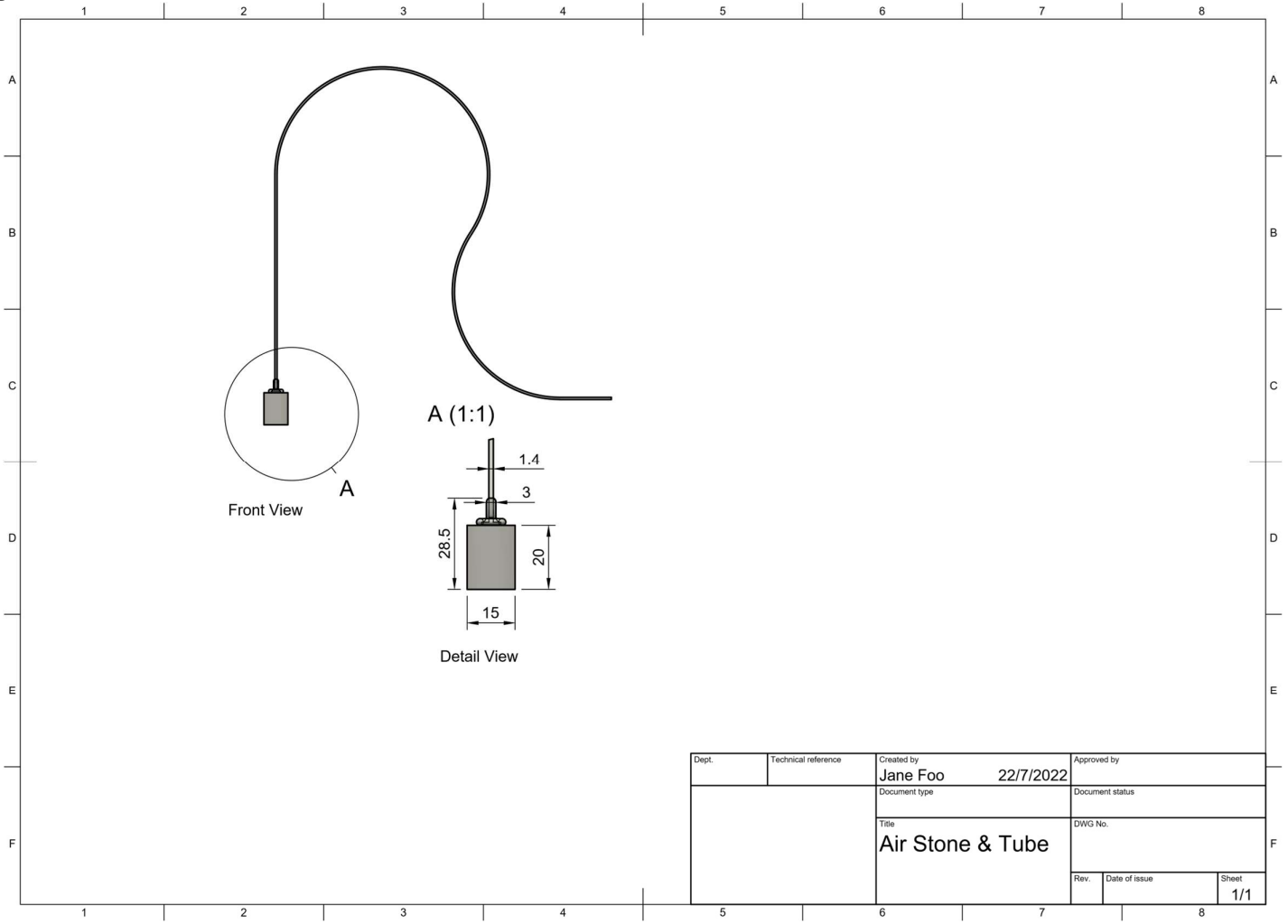


A2.6 Air Stone & Air Tube

A2.6.1 BOM



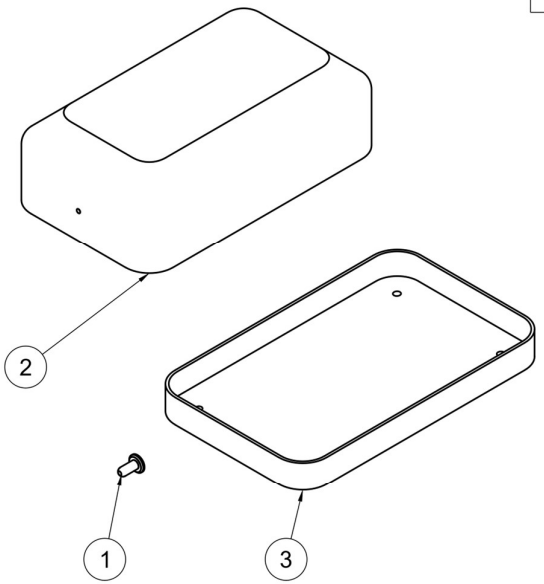
A2.6.2 Drawing



A2.7 Air Pump

A2.7.1 BOM

Parts List				
Item	Qty	Part Number	Description	Material
1	1	Nozzle		Plastic, Opaque White
2	1	Casing		Plastic
3	1	Rubber Base		Rubber, Black



Dept.	Technical reference	Created by: Jane Foo 26/7/2022	Approved by
		Document type	Document status
		Title: Air Pump	DWG No.
			Rev. / Date of issue / Sheet: 1/1

A2.7.2 Drawing