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Dzakovich Lab 3D Printed Hydroponics System Setup V.2

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✓ Peer-reviewed method

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We use this protocol and it's working

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Abstract

This protocol provides step by step instructions needed to assemble the Dzakovich Lab's Single Tower and Double Tower 3D printed hydroponics systems.



Materials

3D printer (FDM, PLA and/or PETG-compatible) — for fabricating all printed components from .STL files

-Single Tower: <https://3d.nih.gov/entries/3DPX-021941>

- Double Tower: <https://3d.nih.gov/entries/3DPX-021942>

M5 screws (25 mm length) — 6 required for Single-Tower, 8 for Double-Tower

M5 nuts — 6 required for Single-Tower, 8 for Double-Tower

M5 Allen wrench — for tightening screw heads during lid assembly

Adjustable wrench — for securing nuts during tightening

Silicon sealant — for sealing seams between lid and spacer modules

Silicon sealant extruder/tube — for applying sealant

Aluminum foil or dark opaque paint — optional, for light proofing lid

Box cutter or similar cutting tool — for trimming vinyl tubing and modifying bin

Flexible vinyl tubing (½" inner diameter) — used for nutrient solution flow; exact length depends on tower height

Hydroponic pump — user's choice, placed at bottom of bin

250-500-gram weight — (optional) used to secure Tower Lid module after assembly

Storage bin (e.g., ULine S-20588GR) — used as the base reservoir

Rotary tool with cutoff disc — used to remove bin lid hinges and rim tabs

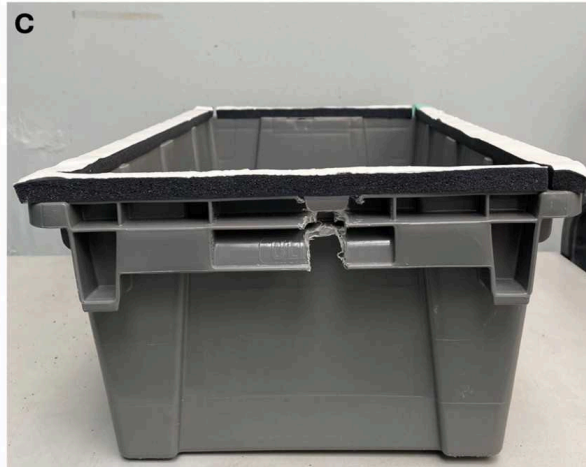
Foam weather stripping (¾" wide × ⅞" thick) — for lining the bin rim

Soft cloth or sponge — for cleaning interior bin surfaces

PVC T-joint (½" inner diameter) — required only for Double-Tower tubing setup

Bin Preparation (ULine S-20588GR)

- 1 Remove the original bin lid by clipping the hinges with wire cutters and discarding or repurposing the lid pieces.
- 2 Remove plastic tabs on the rim of each bin using a rotary tool with a cutoff cutting disc.
- 3 Cut a notch approximately 2 cm by 4 cm out of the rim along one side of the bin (confirm notch alignment with the figure in step 4) for the pump power cord.
- 4 Line the rim of each bin with 3/4" wide x 7/16" thick foam weather stripping.



- 5 Wipe the inner surfaces of the bin to remove any stray plastic that could interfere with nutrient solution pumps with a soft cloth or sponge to avoid scratching the plastic surface.

Printing Setup and Specifications Directory

- 6 Download all files from the 3D-parts (.STL) directory.
- 7 Import files into a 3D-Slicer of choice and set infill to 20%.



- 8 For Single-Tower printing instructions follow steps 10-11, and for Double-Tower printing instructions follow steps 12-13.

Printing Instructions (Single-Tower)

- 9 Slice and print the following for the Single-Tower Lid: x2 Reservoir Spacer Long-Edge (Reservoir_Spacer_Long_Edge.stl; Part 8), x2 Reservoir Spacer Short-Edge (Reservoir_Spacer_Short_Edge.stl; Part 12), x2 Reservoir Lid Left (Reservoir_Lid_Left.stl; Part 9), x1 Reservoir Lid Right Access Hole (Reservoir_Lid_Right_Access_Hole.stl; Part 10), x1 Reservoir Lid Right (Reservoir_Lid_Right.stl; Part 11), and x1 Access Hole Cap (Access_Hole_Cap; Part 13).
- 10 Slice and print the following for a standard 3-module-stacked Planting Tower: x3 4-cup ST Planting Module (4-Cup_Planting_Module.stl; Part 1), x2 Tower Short Spacer (Tower_Short_Spacer.stl; Part 5), x12 Standard Pot (Standard_Pot.stl; Part 6), x1 Stream Breaker (Stream_Breaker.stl; Part 4), x1 Tower Distributor (Tower_Distributor.stl; Part 3), x1 Tower Lid (Tower_Lid.stl; Part 2), and x1 Tower Adaptor (Reservoir_Tower_Adaptor.stl; Part 7).

Printing Instructions (Double-Tower)

- 11 Slice and print the following for the Double-Tower Lid: x1 Reservoir Lid DT Right (Reservoir_Lid_DT_Right.stl; Part 18), x2 Reservoir Lid DT Left (Reservoir_Lid_DT_Left.stl; Part 19), x2 DT Spacer Long-Edge (DT_Spacer_Long_Edge.stl; Part 20), x4 DT Spacer Short-Edge (DT_Spacer_Short_Edge.stl; Part 21), x2 Reservoir Lid DT Middle (Reservoir_Lid_DT_Middle.stl; Part 22), x2 DT Spacer Middle (DT_Spacer_Middle_Edge.stl; Part 23), x1 Reservoir Lid DT Right Access Hole (Reservoir_Lid_DT_Right_Access_Hole.stl; Part 25).
- 12 Slice and print the following for a standard 3-module-stacked Planting Tower: x6 4-cup DT Planting Module (DT_4-Cup_Planting_Module.stl; Part 24), x4 Tower Short Spacer (Tower_Short_Spacer.stl; Part 5), x24 Standard Pot (Standard_Pot.stl; Part 6), x2 Stream Breaker (Stream_Breaker.stl; Part 4), x2 Tower Distributor (Tower_Distributor.stl; Part 3), x2 Tower Lid (Tower_Lid.stl; Part 2), and x2 Tower Adaptor (Reservoir_Tower_Adaptor.stl; Part 7).

Assembly Specifications Directory

- 13 For Lid assembly instructions involving the Single-Tower design refer to steps 16-44, for Double-Tower design refer to steps 68-90.



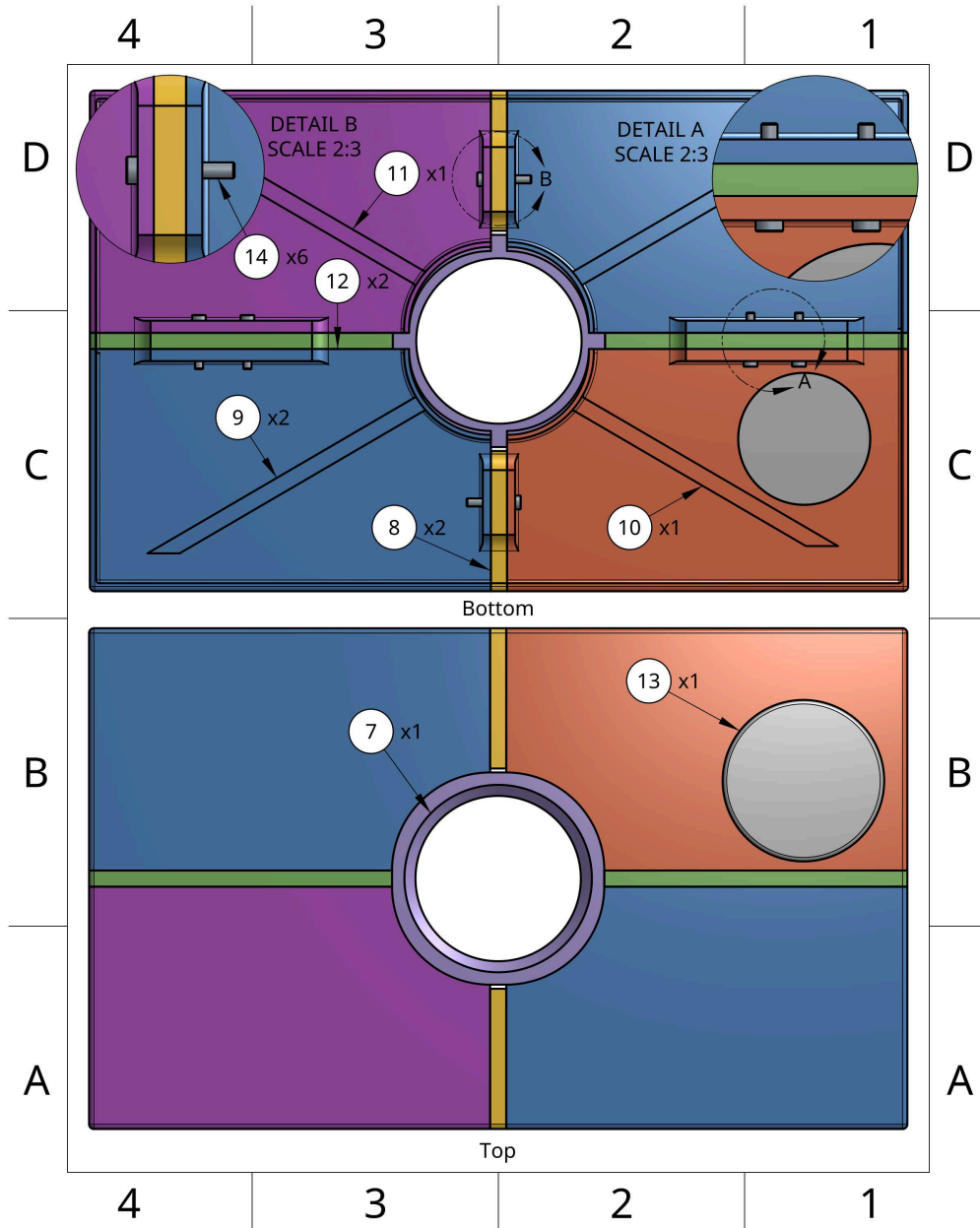
- 14 For Tower assembly and tubing routing instructions involving the Single Tower design refer to steps 45-67, for Double-Tower design refer to steps 89-106.

Lid Assembly Instructions (Single-Tower)

- 15 Gather the printed components from step 10 and the Tower Adaptor (Part 7) from step 11.
- 16 Gather 6 × M5 screws (25-mm long) and 6 × M5 nuts.
- 17 Gather an M5 Allen wrench, Silicon Sealant Tube/Extruder, and either a sheet of aluminum foil or dark paint.
- 18 Place all lid modules upside down on a flat surface.
- 19 Arrange the lid modules in a 2×2 configuration: Top-left corner: Reservoir Lid Left (Part 9), Top-right corner: Reservoir Lid Right (Part 11), Bottom-left corner: Reservoir Lid Right Access Hole (Part 10), Bottom-right corner: Reservoir Lid Left (Part 9).
- 20 Insert one Long Edge Spacer (Part 8) between the top-left and top-right lid modules (along the top edge, long axis).
- 21 Insert the second Long Edge Spacer (Part 8) between the bottom-left and bottom-right lid modules (along the bottom edge, long axis).
- 22 Insert one Short Edge Spacer (Part 12) between the top-left and bottom-left lid modules (along the left edge, short axis).
- 23 Insert the second Short Edge Spacer (Part 12) between the top-right and bottom-right lid modules (along the right edge, short axis).
- 24 Align all bolting tabs on the underside of the lid and spacer modules where they meet.
- 25 Firmly press together each pair of adjacent lid and spacer modules to ensure tight contact.



- 26 Insert an M5 screw through each of the 5 aligned bolting tab holes (where lid modules meet spacers).
- 27 Thread an M5 nut onto the exposed end of each screw from below the assembly.
- 28 Use an M5 Allen wrench to hold each screw head in place.
- 29 Use an adjustable wrench to tighten each nut to hand-tightness (do not over-tighten).
- 30 Locate the Tower Adaptor module (Part 7).
- 31 Insert the Tower Adaptor (Part 7) into the central "cross" opening formed by the four lid modules.
- 32 Ensure the Tower Adaptor is seated evenly and flush with the surrounding lid.
- 33 Confirm you have completed the module correctly by referring to the figure below.



- 34 Prepare a silicon sealant bead approximately 1-mm thick.
- 35 Apply silicon sealant along all interior joints between the lid modules and spacer modules.

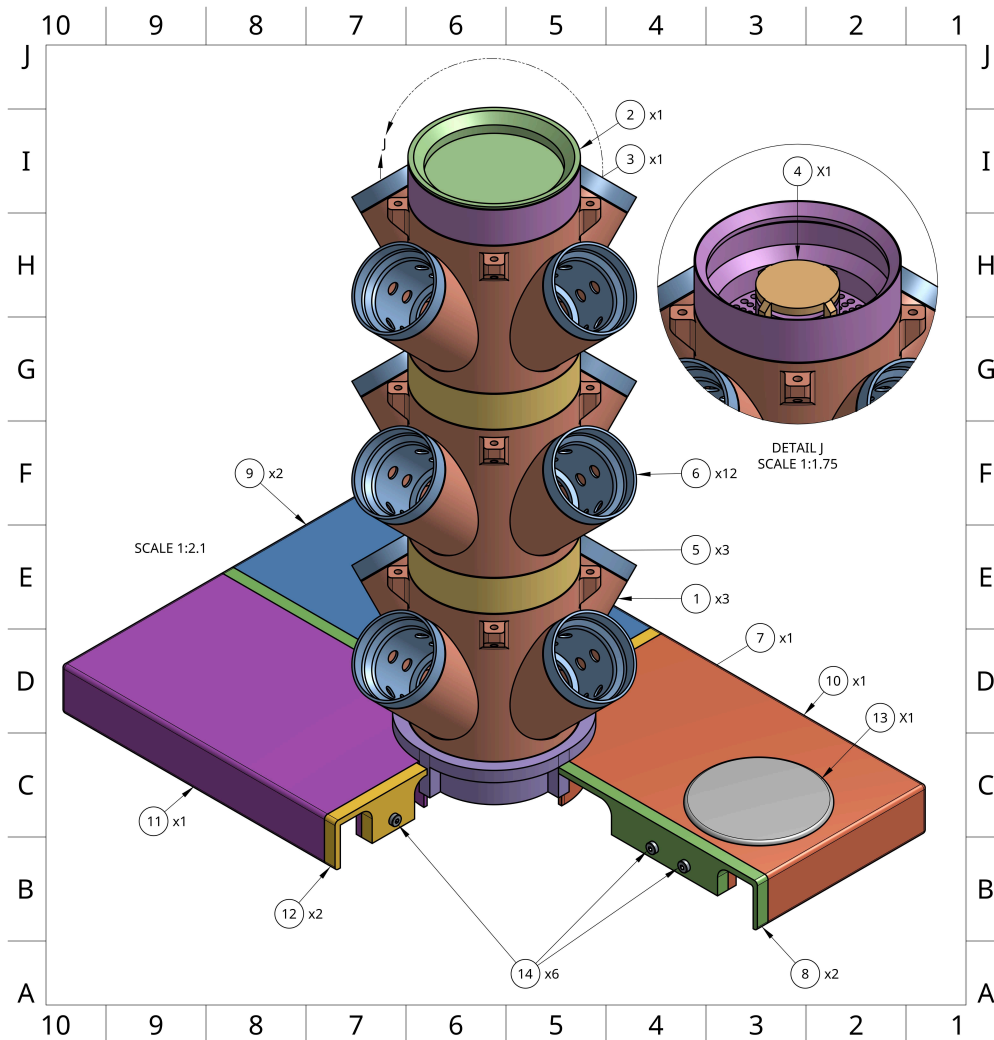


- 36 Apply silicon sealant along all exterior joints on the outside faces where modules meet.
- 37 Apply sealant around the outer radial seam where the Tower Adaptor (Part 7) interfaces with the lid surface.
- 38 Allow sealant to cure per manufacturer's recommendations before further handling.
- 39 Lightproof the lid by one of the following methods: Cover the top surface of the lid with aluminum foil; Paint the lid using dark-colored, opaque paint.
 - 39.1 Alternatively, print lid components using a dark filament.
- 40 Locate the Access Hole Cap module (Part 13).
- 41 Place the Access Hole Cap over the access hole (on the Reservoir Lid Right Access Hole module (Part 10)).
- 42 Ensure the cap fits snugly to prevent solution evaporation and block ambient light.

Tower Assembly and Tubing Instructions (Single-Tower)

- 43 Gather the printed components from step 11.
- 44 Gather a box cutter (or similar cutting tool), a spool of ½" inner diameter flexible vinyl tubing, a ~250-500-gram weight, and the user's choice of pump.
- 45 Place the base Planting Module (Part 1) into the Tower Adaptor (Part 7) on top of the lid.
- 46 Attach a Tower Spacer Module (Part 5) on top of the base Planting Module (Part 1).
 - 46.1 Spacer modules are optional and available in multiple sizes to suit the user's needs.

- 47 Stack the next Planting Module (Part 1) on top of the spacer (Part 5).
- 48 Repeat steps 48-49 an additional time.
- 49 Once stacking is complete, place the Tower Distributor Module (Part 3) on top of the final Planting Module (Part 1).
- 50 Insert Planting Cups (Part 6) into the cavities along the Planting Modules (Part 1).
- 51 Confirm the setup is correct by referring to the figure below.





- 52 Measure the total height of the tower stack from the top of the Tower Distributor (Part 3) down through the modules to the bin floor.
- 53 Add 15-cm to the measured height to account for internal routing and flexibility.
- 54 Cut the ½ inch vinyl tubing to this length.
- 55 Connect the top end of the tubing to the nipple fitting located on the underside of the Tower Distributor Module (Part 3).
- 56 Thread the tubing downward through the central brackets of each module — passing through each Tower Spacer (Part 5) and Planting Module (Part 1) until it exits from the bottom of the tower.
- 57 Place the hydroponics pump into the bin such that the output nozzle is centered on the bin floor.
- 58 Route the power cable of the pump through the notch cut in the bin rim.
- 59 Lower the entire lid + tower assembly into position on the bin, aligning it securely with the bin walls.
- 60 Connect the bottom end of the vinyl tubing to the output nozzle of the pump.
- 61 Check for proper slack and avoid kinking: If the tubing is too long, disconnect it from the pump, trim the excess, and reconnect; Ensure the tubing lies without tension and allows the pump to sit flat.
- 62 Place the Stream Breaker Module (Part 4) on top of the Tower Distributor Module (Part 3).
- 63 Place the Tower Lid Module (Part 2) on top of the Stream Breaker (Part 4).
- 64 Add a weight (~250-500 grams) on top of the Tower Lid (Part 2) to secure the upper modules against displacement from water pressure.

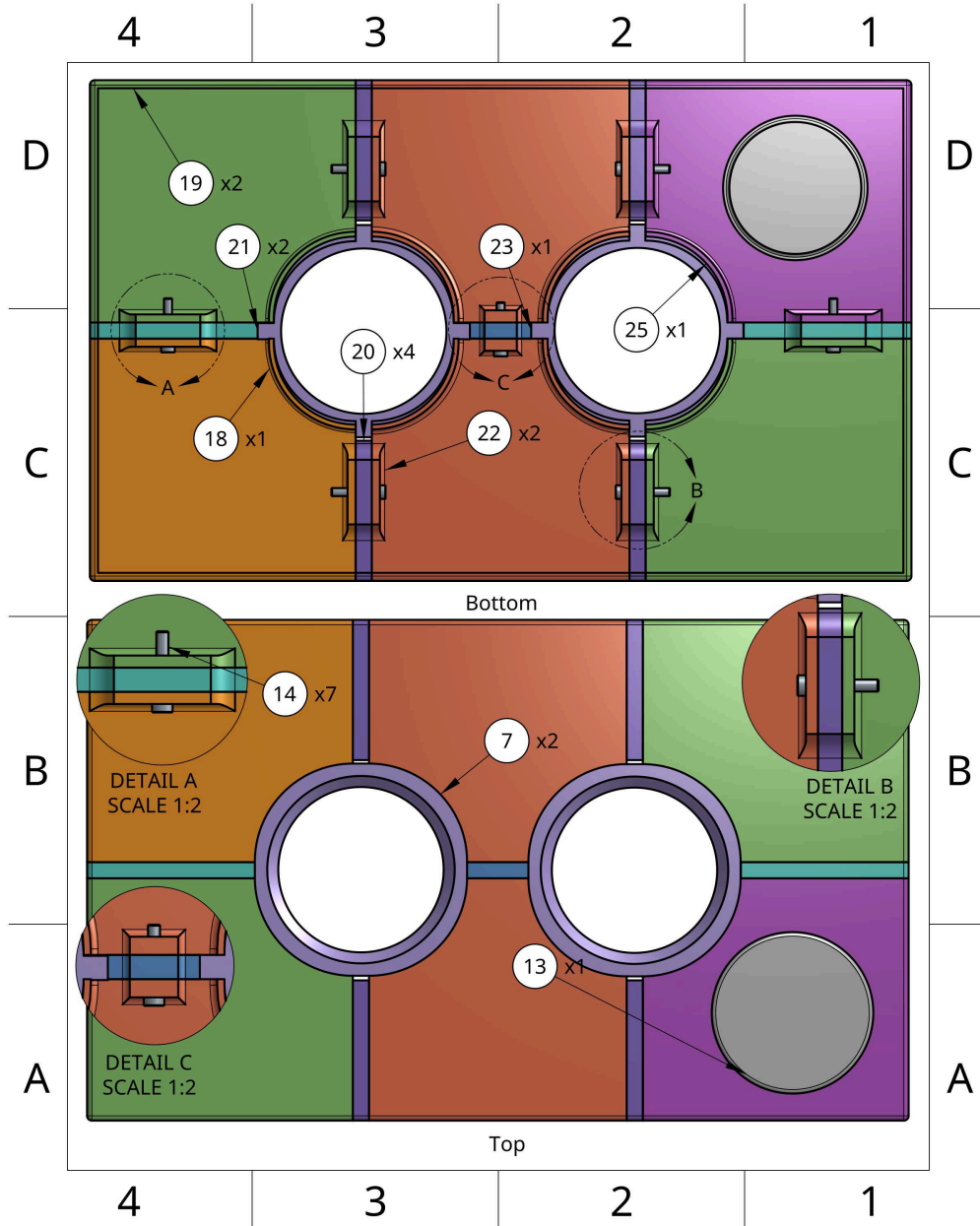
- 64.1 Alternatively, seal lid with thin layer of silicone. A razor blade or other sharp object can cut through the silicone seal for system deconstruction and maintenance.

Lid Assembly Instructions (Double-Tower)

- 65 Gather the printed components from step 12 and the two Tower Adapter modules from step 13.
- 66 Gather 8 × M5 screws (25-mm long) and 8 × M5 nuts.
- 67 Place all lid modules upside down on a flat surface with bolting tabs facing up.
- 68 Arrange the 6 lid panels in a 2×3 configuration: Top Row: Reservoir Lid DT Left (Part 19) → Reservoir Lid DT Middle (Part 22) → Reservoir Lid DT Right (Part 18); Bottom Row: Reservoir Lid DT Left (Part 19) → Reservoir Lid DT Middle (Part 22) → Reservoir Lid DT Right Access Hole (Part 25).
- 69 Insert one Short Edge Spacer (Part 20) between the top and bottom DT Left modules (vertical joint).
- 70 Insert the second Short Edge Spacer (Part 20) between the top and bottom DT Middle modules (vertical joint).
- 71 Insert one Long Edge Spacer (Part 21) between the top-left and top-middle panels (horizontal joint).
- 72 Insert a second Long Edge Spacer (Part 21) between the top-middle and top-right panels (horizontal joint).
- 73 Insert a third Long Edge Spacer (Part 21) between the bottom-left and bottom-middle panels (horizontal joint).
- 74 Insert the fourth Long Edge Spacer (Part 21) between the bottom-middle and bottom-right panels (horizontal joint).
- 75 Insert the DT Spacer Middle (Part 23) between the two DT Middle panels (between the towers, center seam).



- 76 Align all tab holes on lid modules and spacer blocks.
- 77 Insert 8 × M5 Screws (Part 14) through the bolting tabs at each spacer joint.
- 78 Firmly press adjacent components together before threading nuts.
- 79 Thread M5 nuts onto the underside of each screw.
- 80 Tighten each screw to hand-tight using an M5 Allen wrench and adjustable wrench (do not over-tighten).
- 81 Locate the two Tower Adaptor modules (Part 7).
- 82 Insert one of the Tower Adaptors (Part 7) into the left-most “cross” opening, and insert another into the adjacent opening to the right.
- 83 Ensure the Tower Adaptor is seated evenly and flush with the surrounding lid.
- 84 Confirm you have completed the module correctly by referring to the figure below.



85 Complete the operations using silicon sealant from steps 36-40.

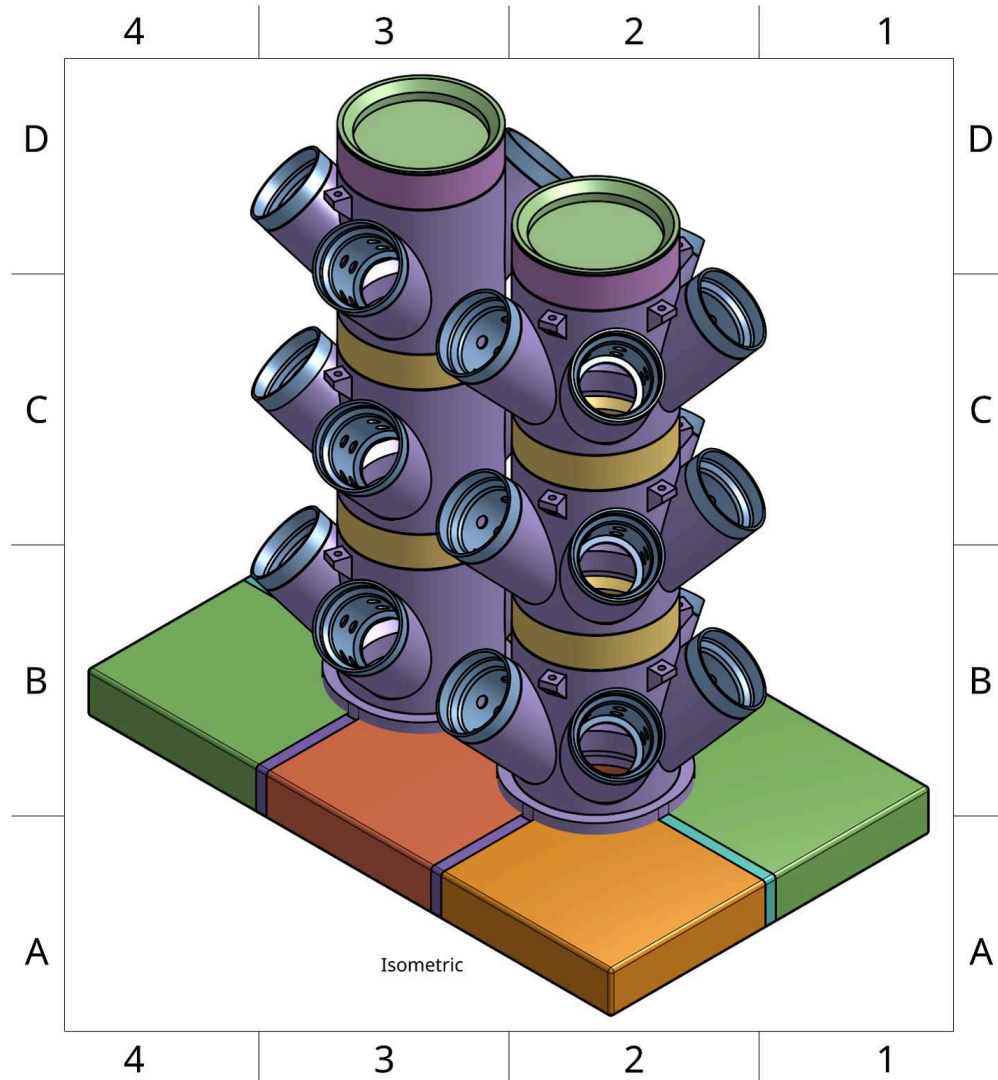
85.1 Optionally light proof with aluminum foil or print components with dark filament.



- 86 Place the Access Hole Cap (Part 13) into the access hole on the bottom-right lid module (Part 25).

Tower Assembly and Tubing Instructions (Double-Tower)

- 87 Gather the printed components from step 13.
- 88 Gather a box cutter (or similar cutting tool), a spool of ½" inner diameter flexible vinyl tubing, a ~250-500-gram weight, the user's choice of pump, and a ½" inner diameter PVC T-Joint.
- 89 Complete the tower assembly operations dictated throughout steps 47-52 for both Tower Modules.
- 90 Confirm the setup is correct by referring to the figure below.



- 91 Measure the total height of the tower stack from the top of the Tower Distributor (Part 3) down through the modules to the bin floor.
- 92 Cut 2 equal lengths of $\frac{1}{2}$ inch inner diameter vinyl tubing — each should be total tower height with an additional 25 cm.
- 93 Connect the top end of each tubing piece to the nipple fitting underneath each Tower Distributor Module (Part 3).
- 94 Thread each tubing piece downward through the tubing brackets inside its respective tower.



- 95 Let each tubing line exit cleanly at the bottom end of its tower.
- 96 Attach both tubing lines to the ½" t-fitting, ensuring equal length from both towers to the junction.
- 97 Cut a short third piece of tubing from the same material — long enough to reach from the t-fitting to the pump output nozzle.
- 98 Connect this third piece to the bottom outlet of the t-fitting.
- 99 Complete the pump assembly operations dictated throughout steps 60-62.
- 100 Connect the short tubing line from the t-fitting to the output nozzle of the pump.
- 101 Check that tubing lengths allow the pump to sit flat at the bottom without kinking.
- 102 If tubing is too long, trim the excess and reconnect all ends.
- 103 Complete final operations dictated throughout steps 65-67.