

# MEGAMENGER

## Overview: level-1 Menger sponge

The **level-1 Menger sponge** is the first iteration of the three-dimensional Menger fractal. It is made of 20 cubes arranged in the shape of a cube with holes through the middle in each direction. When building it out of business cards, we need to panel the 24 internal faces to strengthen the structure. Of course, if you aren't planning on linking the level-1 sponge with another structure you can panel the 48 outside faces as well.

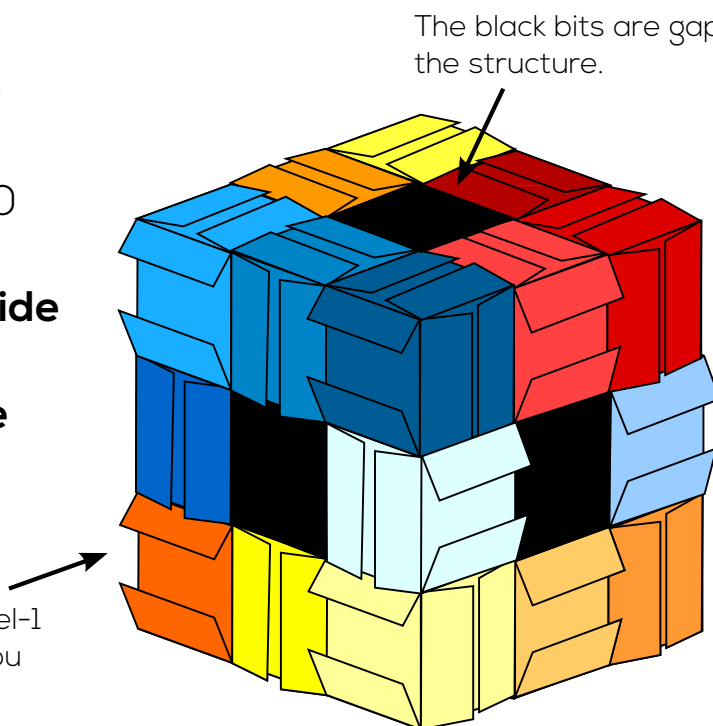
**Number of cubes in each level-1:** 20

**Total number of business cards:** 120

**Panelling cards needed to panel inside the holes:** 24

**Panelling cards needed to cover the outside faces:** 8 per face

Whichever way you build your level-1 sponge it will look like this when you are done!



We have come up with three ingenious ways to build the level-1 Menger sponge:

- 1. Cube-by-cube construction** - you link 20 cubes, one at a time, panelling the appropriate internal faces as you go along.
- 2. Layer-by-layer construction** - you build the bottom ring first, then add four supporting cubes and, finally, another ring of cubes at the top (again remembering to panel the necessary faces).
- 3. Tripod construction** - you build and panel four 'single tripods', each consisting of four cubes, and link them together with an additional 4 cubes.

You can find a video of the cube-by-cube construction at [www.megamenger.com](http://www.megamenger.com), and we have made instruction sheets for the other two techniques. Feel free to use whichever one you prefer!

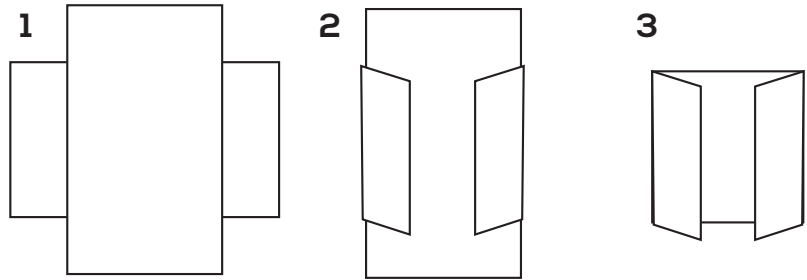
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## Making cube units

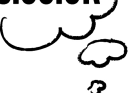
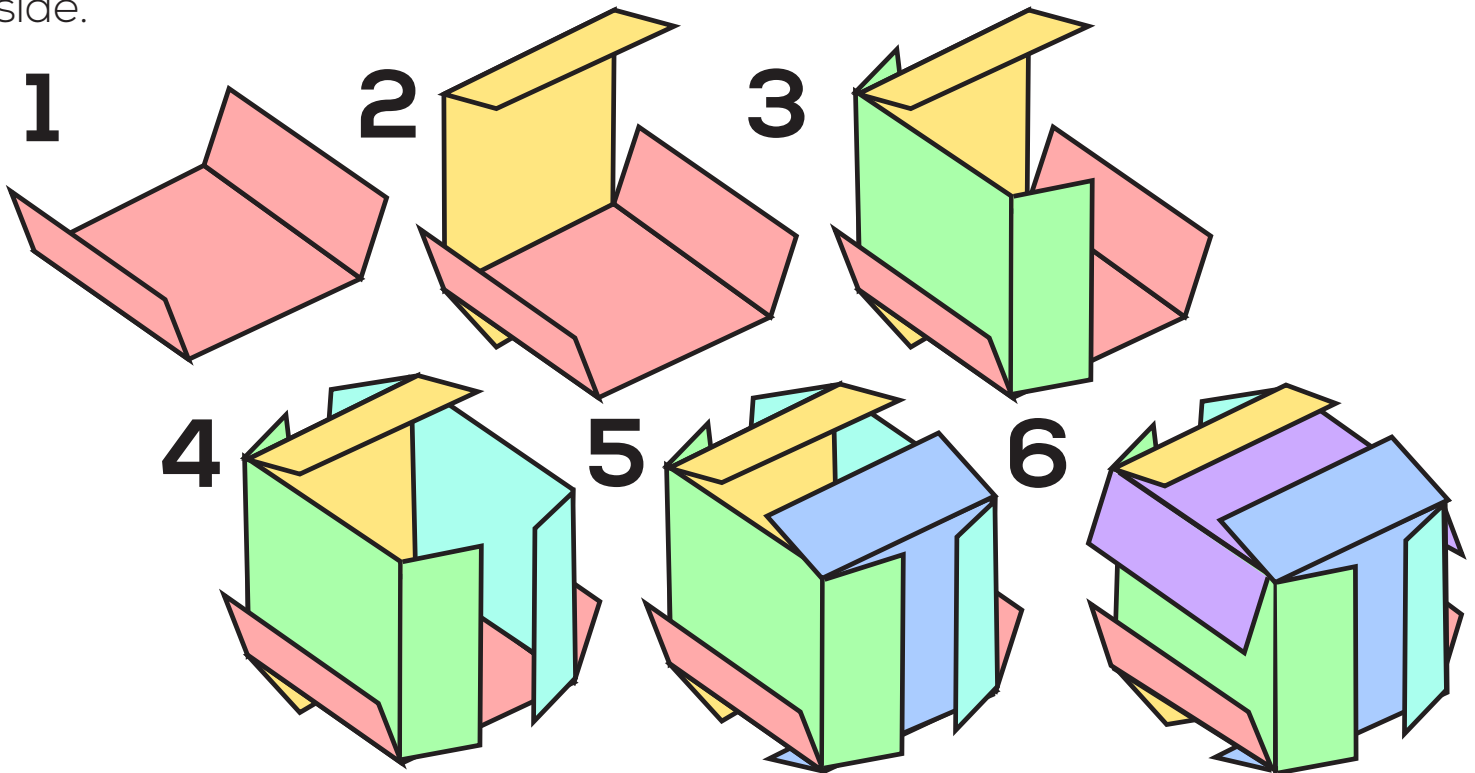
This is a method for building cubes from pieces of rectangular card. These can be used to build the Menger Sponge - you need 8,000 for a Level 3 sponge, or 400 for a Level 2. Let's get cubing!

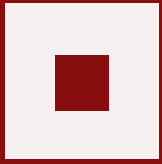
### How to make square units



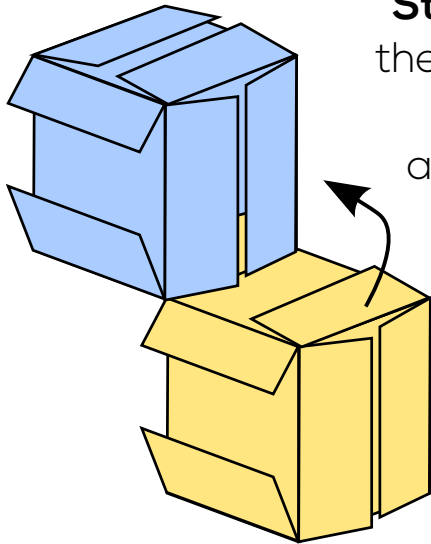
If you place two rectangular cards across each other at right angles, the area where they overlap in the middle is square. If you then fold the sides in you will get a square with tabs!

You can build the cards into a cube, always leaving the tabs outside, and always placing a tabbed end of a rectangle against a non-tabbed side.



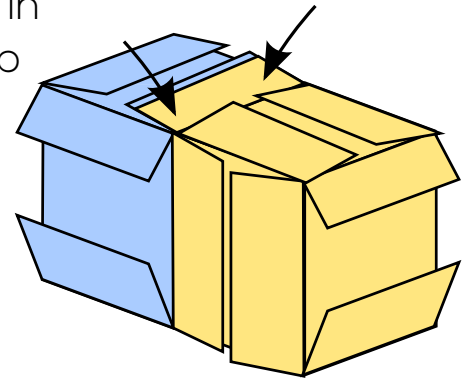


## How to attach cubes

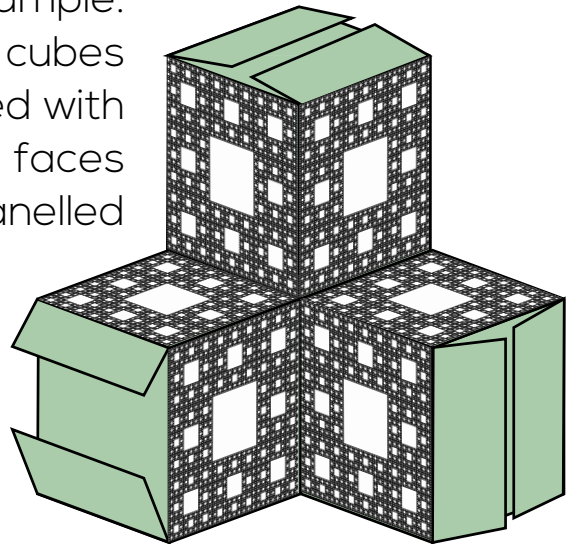


**Step 1:** Insert the tab of one cube into another, and swing the cube up.

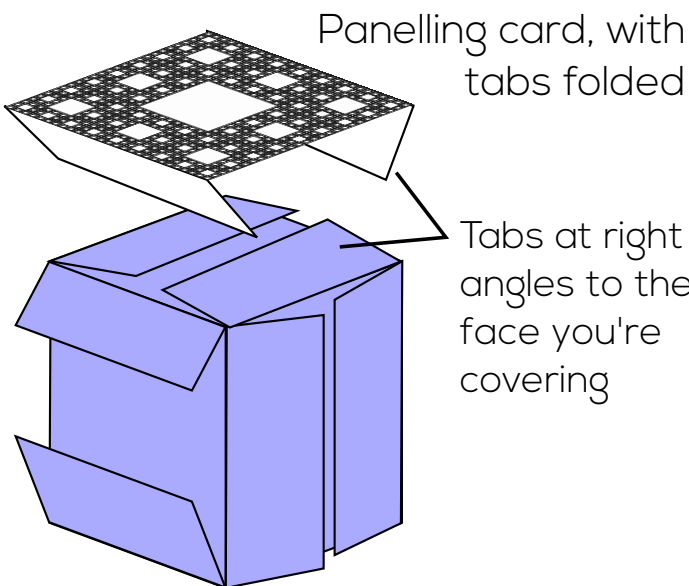
**Step 2:** Tuck in the other tab at the top.



Example:  
four cubes  
joined with  
some faces  
panelled



## Panelling the surface



Panelling card, with tabs folded

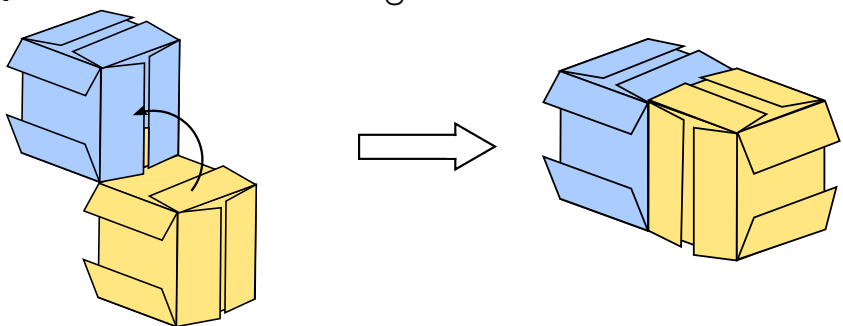
Tabs at right angles to the face you're covering

To make your constructions stronger, and to make the outsides look like they have more fractal layers, you can use the printed cards to cover the cubes. You'll need to fold the edges of the printed cards, just like you did for the blank ones, so that the design is on the outside.

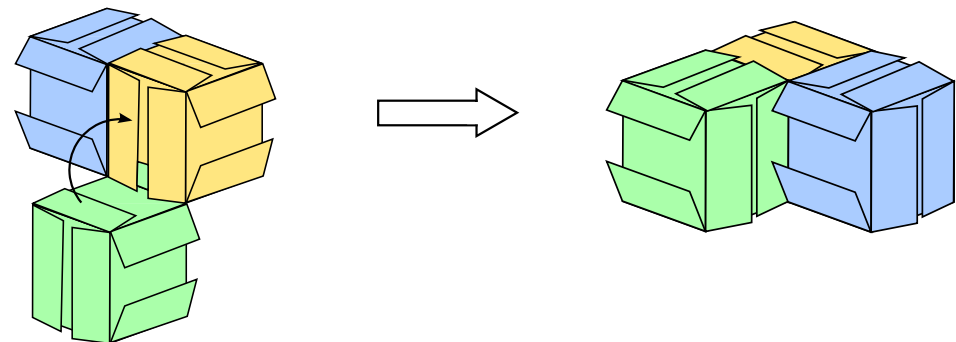
## How to build a single tripod

**WARNING:** Don't build a mirror image by accident! It will not link with other tripods. When you look at the tripod in the last step, the tabs must be horizontal on the left and vertical on the right.

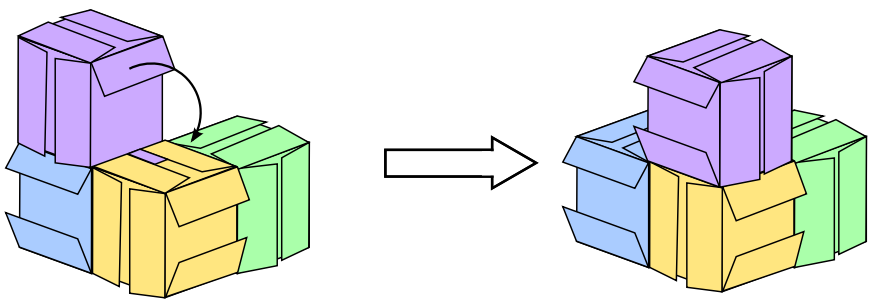
**Step 1.** Link two cubes together to build a column.



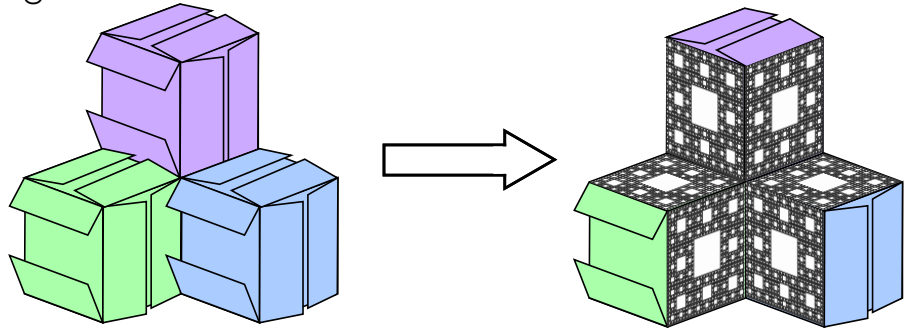
**Step 2.** Link a third cube to the column to form a base.



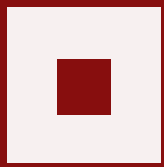
**Step 3.** Add the fourth cube to the base.



**Step 4.** Panel the six internal faces of your tripod before joining it to other structures.



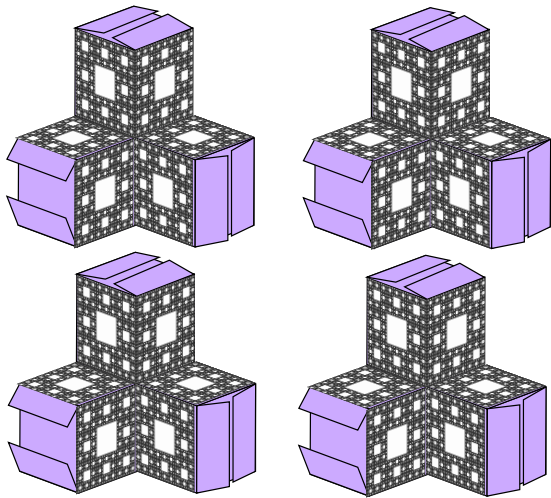
Don't forget to put both tabs in when you are linking cubes together!!



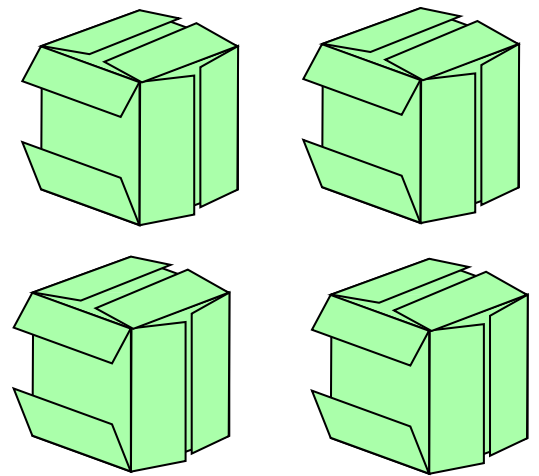
## Tripod construction method: level-1 sponge

Building the level-1 Menger sponge layer-by-layer might not appeal to you. Fortunately, Jeannine Mosely, the first person known to have constructed a level-3 Menger sponge, came up with a way to construct them using building blocks called "Tripods". For the level-1 sponge we will need the following:

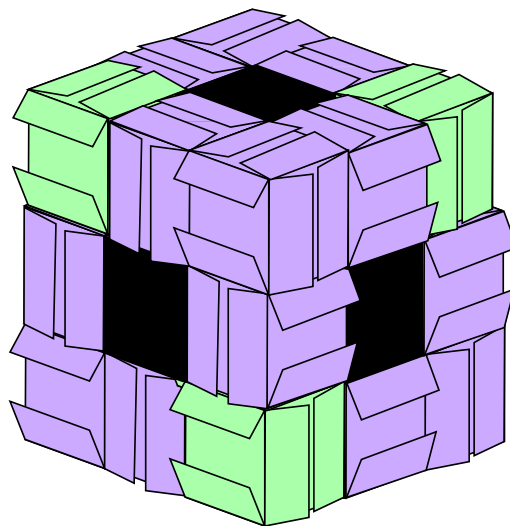
### Panelled single tripods x 4



### Unpanelled cubes x 4

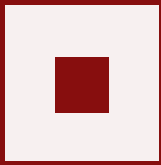


These elements link together to form a level-1 Menger sponge.



There is more than one order in which to put these elements together. We think it is easiest to work from the bottom to the top. We have put together some instructions, but feel free to mix it up. Just remember to keep an eye on the orientation of your building units!

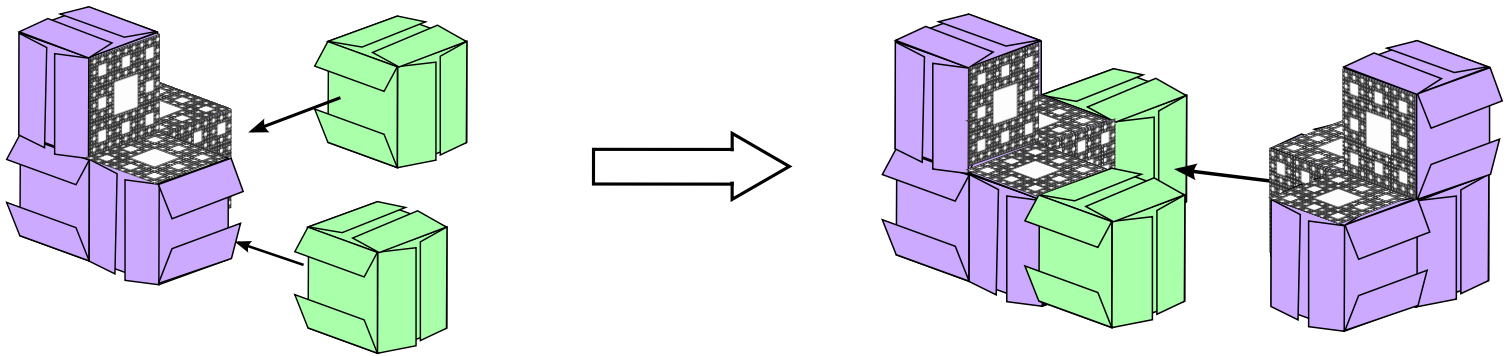
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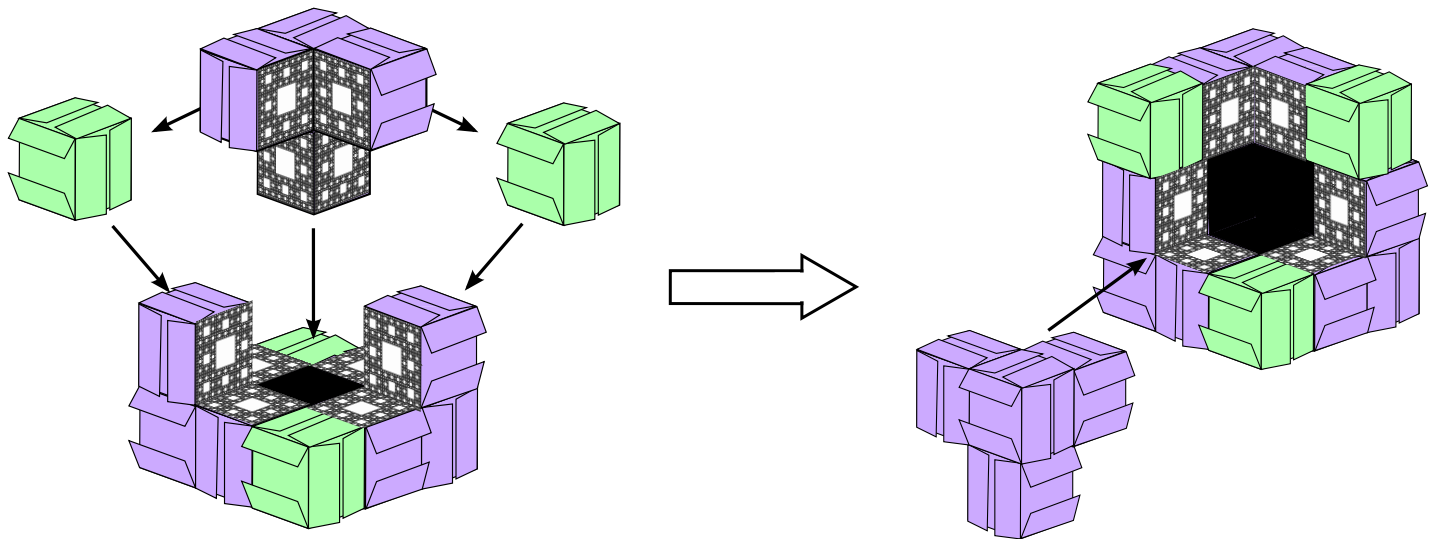
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**Step 1.** You will need to have four unpanelled cubes, and four panelled single tripods.

**Step 2.** Link two panelled single tripods and two unpanelled cubes together as shown below.

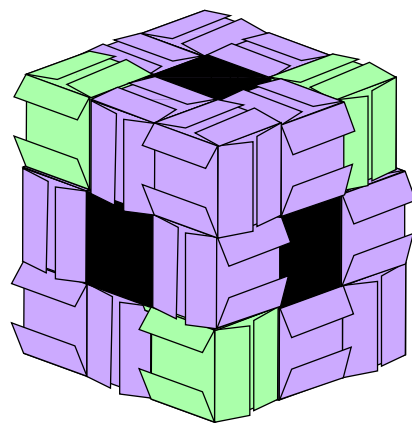


**Step 3.** Attach the remaining elements to the base.

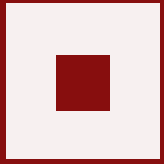


Here's your finished level-1 Menger sponge ready to be linked to a larger structure - or if you are just building a level-1 you can finish off by panelling the outside.

If you find your tripods don't seem to fit together, look at the tripod worksheet again and check they're built the right way round!



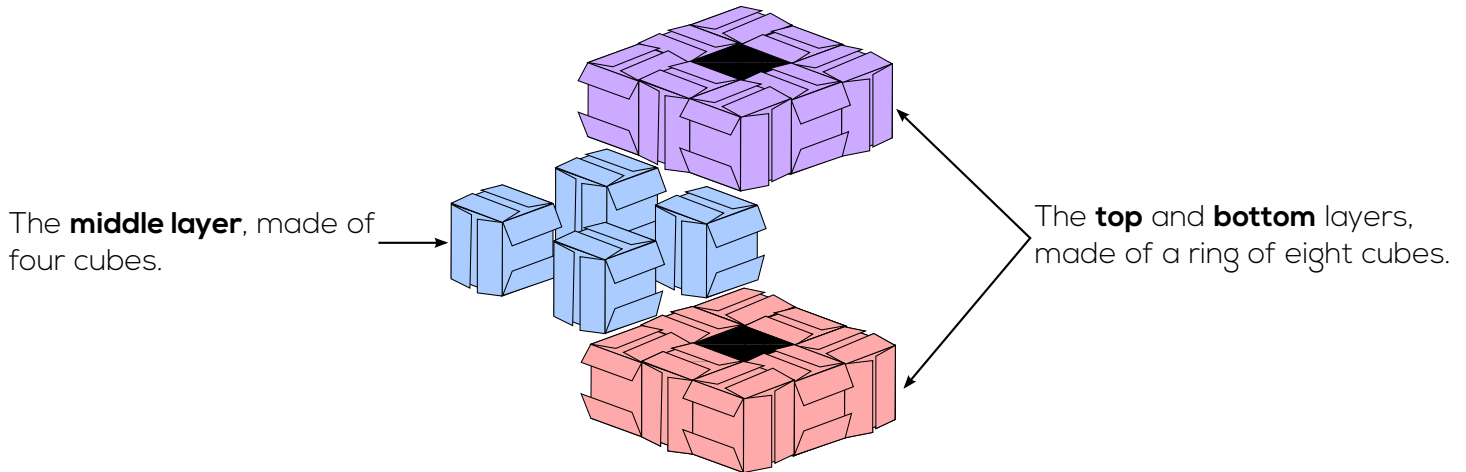
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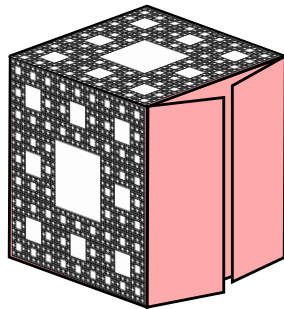
## Layer-by-layer construction: level-1 Menger sponge

In this method, as the name suggests, we build the three layers of the level-1 Menger sponge separately

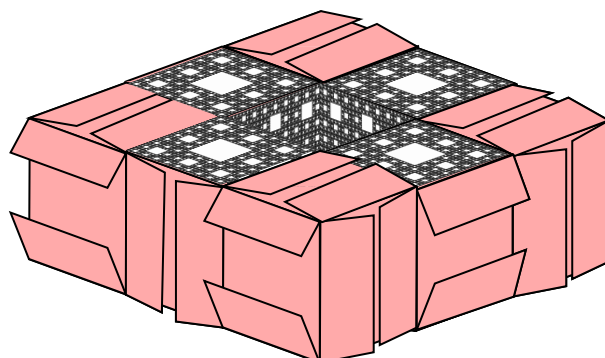


and then stick them together. We also need to clad some of the cubes to strengthen the sponge. We have put together some instructions below showing you how to do this. Of course, there is more than one way to layer the sponge, so feel free to mix it up if you want! Just make sure the end result is the same as what we have shown here.

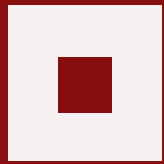
**Step 1.** Build 20 cubes. You will need to double-panel 12 of these (four for each layer).



**Step 2.** Pick four double-panelled cubes and four unpanelled cubes to build a ring. Make sure the unpanelled cubes are at the corners of the ring.



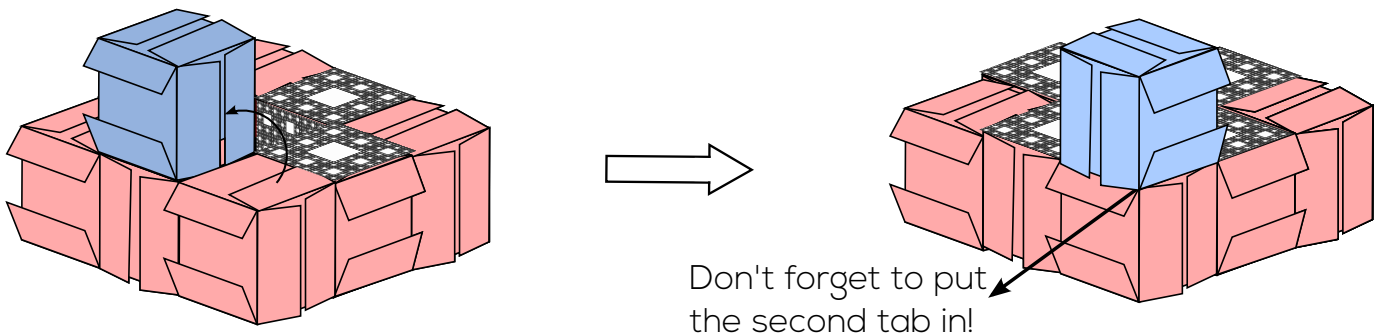
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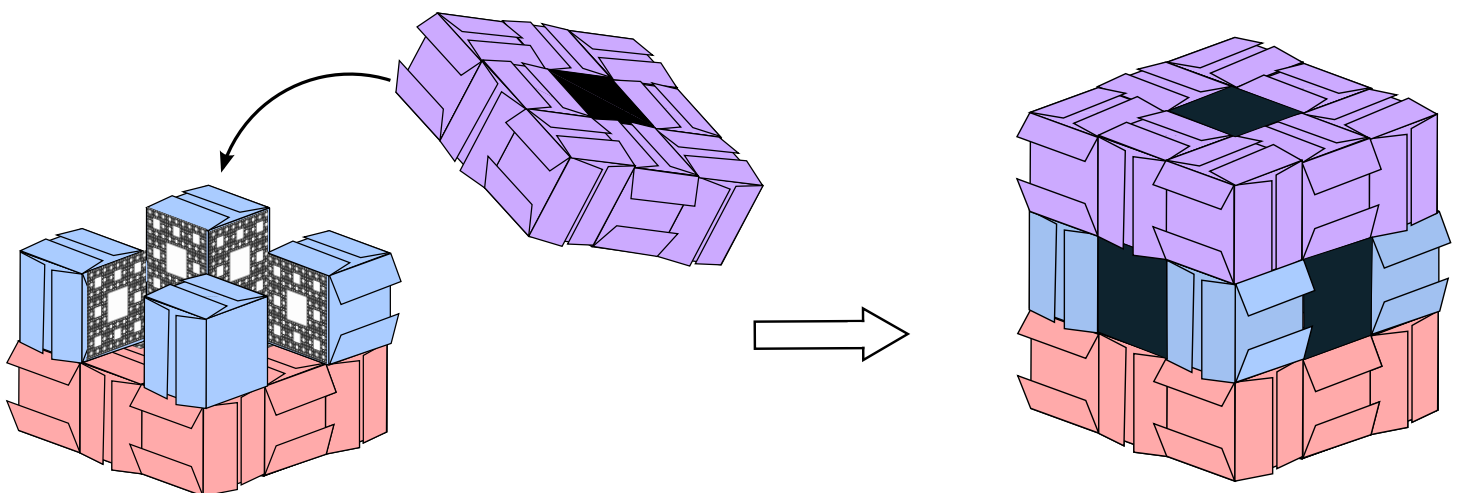
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**Step 3.** Construct a second ring of cubes, which should look the same as step 2, with the panels applied in the same places.

**Step 4.** Now link the remaining four double-panelled cubes to the corners of one of the rings. This can be a bit tricky, as each cube needs two tabs linked to the ring. We think it's easiest to start with the one on the inside first, as shown in the diagram below. Repeat this at the other three corners.



**Step 5.** We now need to put on the final layer. This will rest on top of the base you constructed in the previous steps, with the panelled sides on the underneath.. We prefer to place the ring on top and then work our way around to put in the 8 tabs. It is hard to get the internal tabs, but don't worry if you miss a couple out as the structure should still hold. If all else fails - use TAPE!!!!



Your level-1 Menger sponge is ready to be attached to a larger structure - or if you are just building a level-1 sponge, you can finish off by panelling the outside.

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Worksheets developed by