



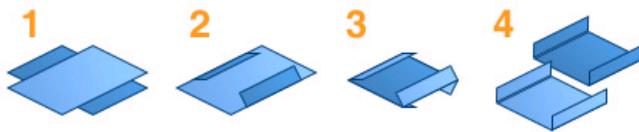
Instructions

As the [About](#) section describes, Menger sponges are made by dividing cubes into smaller cubes. Since this is not really possible with paper, sponges made from paper must be built by joining together many small units, creating larger sculptures. (Any number of structures can be built using cubes, but these instructions focus on building sponges.)

Materials needed

Index cards are all that's needed. [Oxford lined 3x5 index cards](#) work best, however any other type would work well.

Creating the units

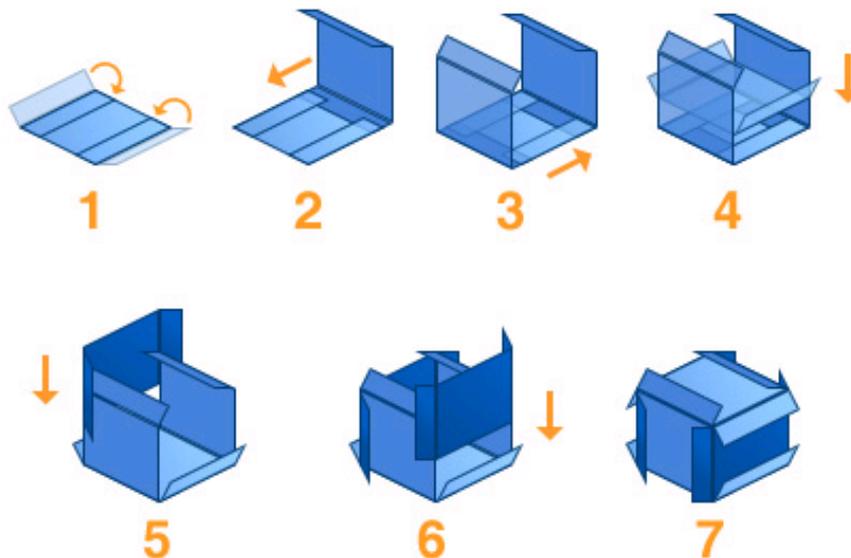


1. Take two notecards and lay one on top of another perpendicularly like a cross.
2. Fold the flaps of the bottom card over the top card.
3. Flip the two units over as a whole and fold the other two flaps over.
4. Separate the units from each other and repeat to create as many as necessary.

Assembling a cube

Each cube comprises **6–10** units. Six units are always required to create the basic cubes but depending on a cube's location in a sponge, it may require up to four additional units for covering exposed flaps.

Assembling cubes can be tricky but it gets easier after a few tries. The following steps describe how to create a cube starting with a covering unit.



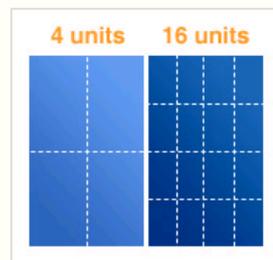
Search this site

Search

Helpful tip

Tearing index cards into 4 or 16 equal pieces before creating units. Your structure will be much more stable.

Do this by folding along the lines below a few times, then tearing them carefully along the folds.



These steps may sound confusing, the diagram help can help you.

1. Fold the first unit's flaps inward and lay it flat with the flaps on top.
2. Slide one of the second unit's flaps inside the first unit's two flaps, then fold the unit up.
3. Slide one side of the third unit's flaps inside the first unit's flaps on the other side. (These three units create a boxy "U" shape with the first unit as the bottom of the U, the second unit as the right side, and the third unit as the left side.)
4. Add the fourth unit in between the second and third units flat against the covering unit without folding the flaps inward, and matching the covering unit's orientation.
5. Slide the fifth unit behind the third and second units, closing off the "back" of the U. Make sure the fourth unit's flap is sticking out on the bottom and the fifth's flaps are hugging the second and third units.
6. Slide the sixth unit in front of the first and second units like the fifth unit, creating a five-sided box with the top open.
7. Open the flaps of the second and third units to add the seventh unit so it lays under them, but on top of and hugging the fifth and sixth units. Close the second and third units' flaps.

If the cube is built correctly, one side should be flat and all other sides should have two exposed flaps hugging a unit. These flaps interlock to create a stable cube.

Attaching cubes

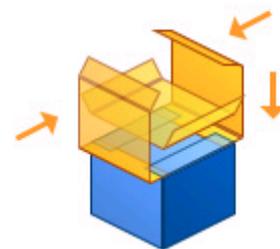
Attaching cubes to each other is how the sponge is built. Cubes can be attached in multiple ways. They can be built separately and attached as whole cubes, but this can get cumbersome and lead to frustration depending on where the cubes reside in the overall structure.

They can also be assembled on other cubes by following the instructions above. The only difference is that instead of using a covering unit to start, use the exposed flaps of an existing cube. From there, follow the rest of the steps like normal to build additional cubes.

The way the flaps interlock creates a strong connection between the cubes eliminating the need for tape or glue.



Attaching a prebuilt cube



Building onto an existing cube

Covering exposed flaps

Covering exposed flaps (or creating paneled sides) is useful for two reasons: it covers the ugly flaps and strengthens the cube. To cover exposed flaps on one side of a cube, use one unit and slide one flap under two exposed flaps just like the first step of assembling another attached cube. Then, fold the other flap of the same unit and slide it under the other side of the exposed flaps on the same side. This can be a little tricky depending on the size of your units.



Attaching a cover

Fun facts

Level	Cubes	Units
0	1	12
1	20	192
2	400	3,456
3	8,000	66,048
4	160,000	1,296,384
5	3,200,000	25,731,072



What is a Menger sponge?

A Menger sponge is a three-dimensional [fractal](#) named for its creator, [Karl Menger](#).

To make a Menger sponge, do the following:

1. Picture a cube.
2. Divide the cube into 27 smaller cubes arranged in a $3 \times 3 \times 3$ setup like a [Rubik's Cube](#).
3. Remove the center cube from each face and the one in the middle of the arrangement.
4. Repeat steps one through three for each of the remaining cubes to create more detailed sponages.



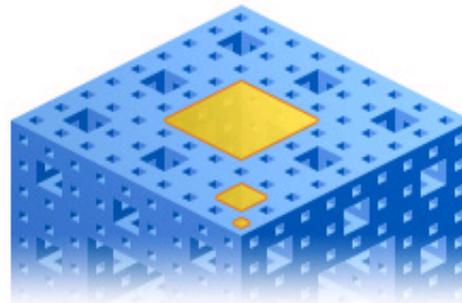
Steps for creating a level one Menger sponge



Steps for creating a level two Menger sponge

Each time the process of dividing and removing cubes is completed, a new "level" of sponge is created. For example, following steps one through three above for a single cube creates a level one sponge (20 cubes). If they're done a second time, a level two sponge is created (400 cubes). This process can be done an infinite number of times resulting in a sponge with an infinite number of cubes and surface area.

To determine the level of a sponge, count the number of gaps that are different sizes. The figure to the right displays a portion of a level three sponge with the three different gaps highlighted in orange.



Level three sponge with counting guide

Basically, units create cubes and cubes create sponges: units » cubes » sponges.

The easiest part of assembly is the first cube, requiring 6–10 units and [a few easy steps](#). Attaching additional cubes can be done three ways:

Pre-assembly

The first method involves building a cube separately and leaving flaps exposed on sides that will interlock with other flaps. Pre-assembling cubes works best for cubes that will interlock with only one set of flaps, such as cubes on the 12 edges of a level 1 sponge.

Note: all cubes end up interlocking with at least two sets of flaps in all sponges, but flaps are exposed during assembly until more cubes are attached so some cubes will interlock with only one other until more are attached to them. For an example, see the [first level four photo](#) with some cubes attached on a single side.

Assembly on the fly

The second and most used method is used for cubes that interlock with two or more sets of flaps. Units should be added to the sponge one at a time.

Trying to attach a pre-assembled cube to multiple sets of flaps is enough to drive anyone mad because it is nearly impossible to make the flaps behave properly. (Don't believe me? Try it...now try it with three sets of flaps.) Assembling on the fly makes life much easier. Most of the time on larger sponges is spent assembling on the fly.

Assembly on the fly

The second and most used method is used for cubes that interlock with two or more sets of flaps. Units should be added to the sponge one at a time.

Trying to attach a pre-assembled cube to multiple sets of flaps is enough to drive anyone mad because it is nearly impossible to make the flaps behave properly. (Don't believe me? Try it...now try it with three sets of flaps.) Assembling on the fly makes life much easier. Most of the time on larger sponges is spent assembling on the fly.