

The Level 3 Menger Sponge Project

The Level 3 Menger sponge A collaborative modular origami project.

- The Menger sponge is a fractal, incorporating self-similarity—that is, there are component parts of the Menger sponge that are rescaled versions of the entire object. Many natural phenomena have fractal characteristics, among them plants, clouds, and mountains.
- To build a Menger sponge, start with a block of 27 cubes, and remove the 6 cubes at the center of each face and the cube at the very center of the block. The 20 cubes that remain form the level 1 Menger sponge. To build the level 2 Menger sponge, take a level 1 Menger sponge and replace each of its 20 cubes with a 1/3 scale level 1 Menger sponge. This process can be repeated: to form the level *n* + 1 Menger sponge, take a level 1 Menger sponge and replace each of its 20 cubes with a 1/3 scale level sponge, take a level 1 Menger sponge and replace each of its 20 cubes with a 1/3 scale level 1 Menger sponge. The Menger sponge is the limit of this process.



Left: Level 1 Menger sponge (20 cubes, overall 6 x 6 x 6 inches) Right: Level 2 Menger sponge (400 cubes, overall size 18 x 18 x 18 inches)

The Lafayette Level 3 Menger sponge will be constructed of 8,000 business card cubes—48,000 cards for the cubes, and 18,000 for paneling. The finished size will be a 54 x 54 x 54 inches.

The basic cube unit is constructed of 6 business cards. To fold business cards: 1. Fold one card carefully in half to make a template 2. Insert a business card, here shown as a blue card, into the template



3. Carefully fold the blue card edges tightly over the top and bottom of the template to form two flaps. (The tighter the folds, the stronger the final cubes)





The finished folded card module. You'll need six of these to form a cube.

Diagram from the *Institute for Figuring*, Los Angeles, website





A basic cube, constructed from 6 business cards. Start with the orange card on the bottom, add the yellow cards next, then the green cards, then insert the final orange card on top. A total of 1600 single cubes will be used to link tripod units.

LINKING CUBES:

Insert a vertical flap into two horizontal flaps, like the blue top cube into the yellow top cube (top right picture). Bring the cube faces together along the hinge, then slide the blue flap into the yellow one to lock the cubes (bottom picture).

IMPORTANT: All adjacent sides should be linked.







A TRIPOD is a block of 4 linked cubes, one at the corner and three attached on the sides. The flaps **must** always be in the configuration shown below. That is, looking at the tripod from behind as in the picture on the left, the hinges on the corner cube should be vertical.

A Level 3 Menger sponge requires 4 tripods.



• The Menger sponge will utilize "tripods" as the basic construction unit.

Vertical hinges

DOUBLE TRIPOD: To build these, start with a single tripod, then add four cubes to make the second tripod. (It's difficult to attach two completed tripods together.)

A Level 3 Menger sponge requires 84 double tripods.



TRIPLE TRIPOD

156 triple tripods are required for the Level 3 Menger sponge.



QUADRUPLE TRIPODS

84 quadruple tripods are required for the Level 3 Menger sponge.



DOUBLE-TRIPLE TRIPODS

72 double-triple tripods are required for the Level 3 Menger sponge.



DOUBLE-DOUBLE TRIPODS

48 double-double are required for the Level 3 Menger sponge.



Alternate instructions for tripod units using rows of 4 cubes and and rows of 2 cubes

2-2 cube units and 2 4-cube units shown here



Hinge a 2-cube unit to a 4 cube unit as shown below

Rotate the 2-cube unit and insert adjoining flaps. The result is a double tripod.





Alternate tripod building instructions

Hinge a 2-cube unit to the 4 cube unit of the double tripod

Rotate and finish by inserting flaps



Attach 4-cube unit to the double tripod

Add 2 cube unit





2 more cubes need to be added

The final 2 cubes unit must be constructed in place. One has been added below





A double-double tripod



 The triple and double-triple tripods; the quadruple tripods can also be constructed using combinations of 4-cube rows, 2-cube rows, with additional single cubes.



PANELING

Adding cards or "panels" to the face of the cubes.



Sign some of the paneling cards

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Add your name to some of the paneling cards.



To panel the tripods, fold the card using the same method for building tripods.





Panel all exposed sides of the tripod corner block—shown in blue on the left, and marked with a red "C" on the right. Panel all of the adjoining sides that touch the corner block. Paneling a cube with an unlinked side. 1. Left: slide card onto flap, fold, exposing "Crease, Fold & Bend" 2. Right: carefully lift pink flap.





3. Slide pink flap into paneling card slot.



Paneling an interior cube.

Slide paneling card over flap

2. Left: fold over the paneling card.
3. Insert green flap into paneling card slot. (Bending the card with a slight convex curve will make inserting the flap easier.)





Panel all sides that touch the corner cube- the unpaneled sides will be used to link tripods together. "X's" mark sides that do not get paneled.



Diagram of Level 2 Menger sponge, by Kevin Hartshorn, Moravian College based on work by Dr. Jeannine Mosley. Dr. Mosley developed the construction method that utilizes tripod units.

In Dr. Hartshorn's color coding notation, blue blocks indicate a single tripod unit; purple blocks are double tripods; yellow blocks are triple tripods; and the red indicates a quadruple tripod. The white blocks are single cubes that link tripods together.

This diagram will serve as one of the guides for constructing the Level 3 Menger sponge.



A level 3 Menger sponge under construction. The Level 2 Menger sponge is the basic unit for assembly. Dr. Mosley taking a break on the right. Photos from the Institute for Figuring, Los Angeles, website







Alternate view of interior







Additional interior views of Level 2 Menger sponge showing location of quadruple tripod (in red)





Dr. Jeannine Mosely, a software engineer, is shown standing in front of a Level 3 Menger sponge. She calculated a method to construct Menger sponges using sub-units or "tripods."



Detailed information about the Level 3 Menger sponge can be found at http://theifl.org/oexhibits/paper06.html

on YouTube, instruction for folding and linking cubes http://youtu.be/RxMgiqIhizO Origami Business Card Cubes 1



http://youtu.be/eRCOt4J2tew Origami Business Card Cubes 2





From left to right: basic tripod unit (purple and orange), basic cube (orange); Level 1 Menger sponge; and Level 2 Menger sponge.

• Many thanks to:

Kevin Hartshorn for permission to use his color-coded drawings of the Level 2 Menger sponge.

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