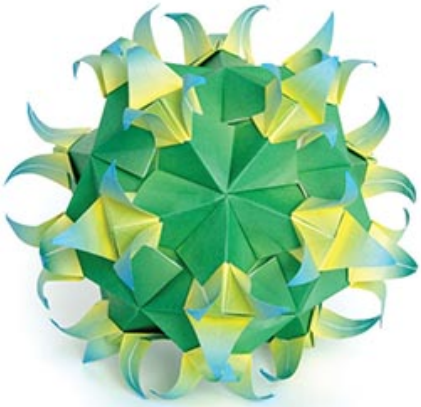

MODULAR ORIGAMI

KALEIDOSCOPE

Ekaterina Lukasheva

EKATERINA LUKASHEVA

MODULAR ORIGAMI KALEIDOSCOPE

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2010: Aristata, Masquerade;
2011: Eve, Prima, Tigra, Tiger;
2012: Almandine, Chameleon Eye, Delicate Flower, Flower Star, Forma Perfecta;
2013: Bicolor, Insignia, Kohleria, Lathyrus, Pulsatilla, Radiant Flower, Secret Flower;
2014: Flora, Flora Flower;
2015: Clematis, Sprouts, Nerium.

Thanks to all the people who helped me make, test fold,
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Alina Maslova
Boris Pavlović
Tanya Turova
Jean Wallace
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Photo credits

Ekaterina Kim: portrait on the cover.
Inna Lupanova: picture on page 38 (top).
Alina Maslova - picture on page 51, page 56.
Tanya Turova: pictures on page 22, page 26, page 30, page 31, page 35, page 38 (bottom), page 39, page 40, page 60, page 50 (bottom), page 64, page 66.
Jean Wallace: the diagrams on page 60, page 48.

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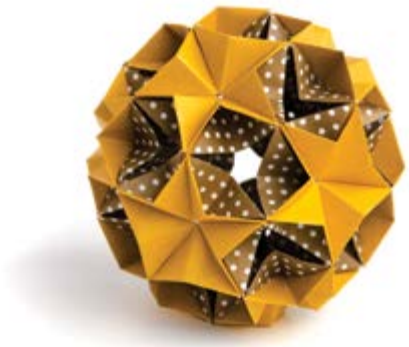

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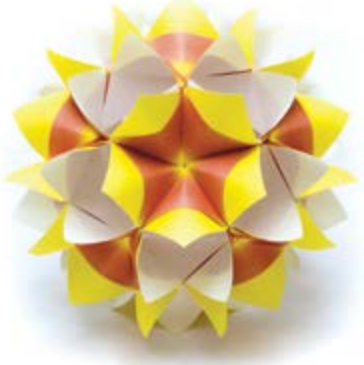

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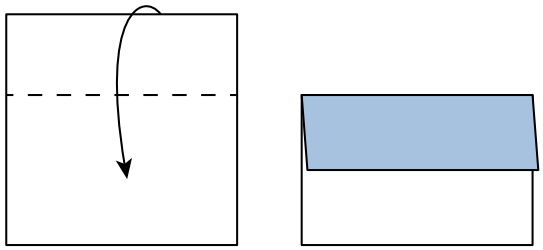
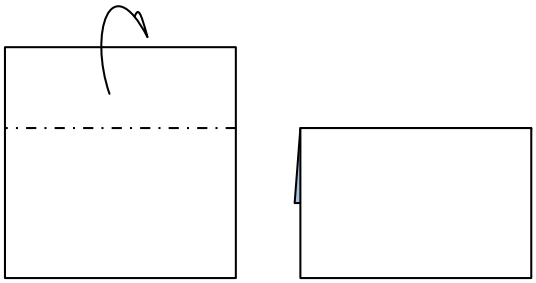
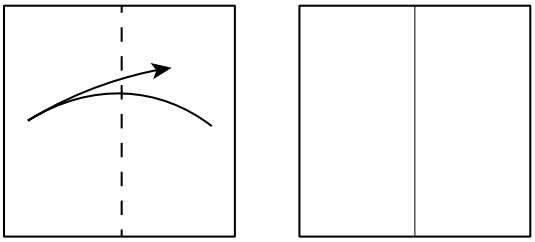
ORIGAMI SYMBOLS



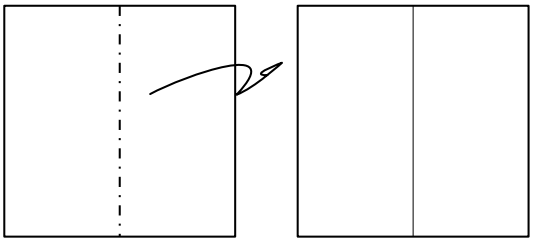
valley fold



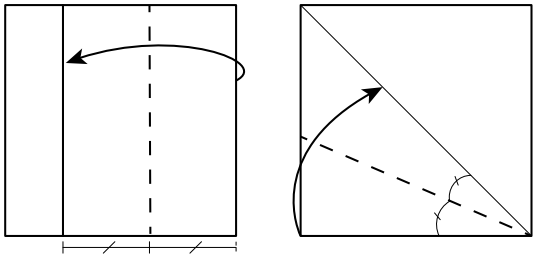
mountain fold



valley fold and unfold

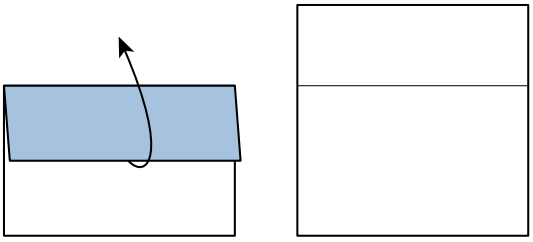


mountain fold and unfold

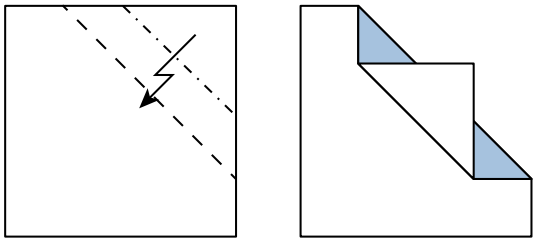


equal lengths

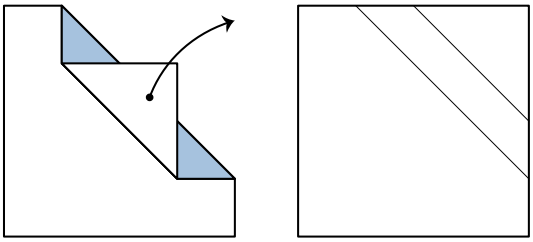
equal angles



unfold



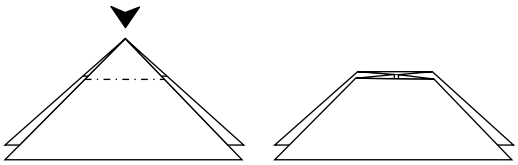
pleat fold



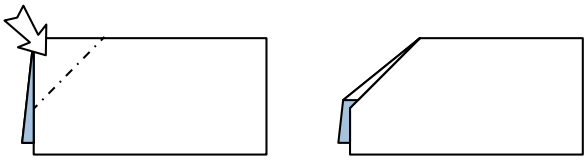
unfold/pull paper

enlarged view ahead

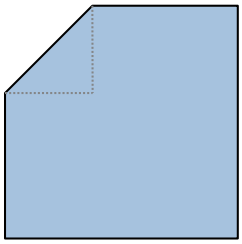
curl



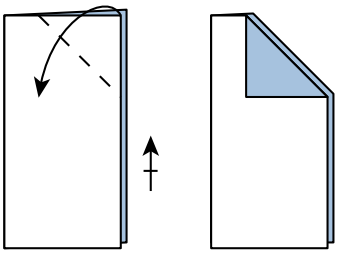
sink fold



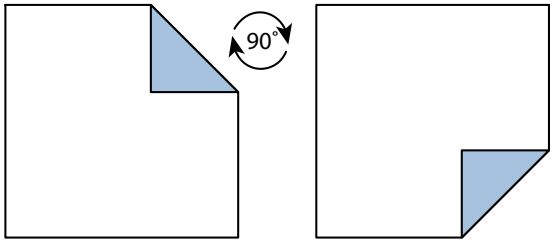
inside reverse fold



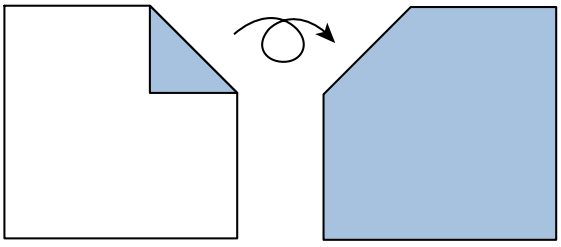
back (hidden) layer



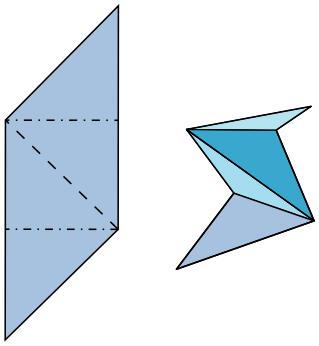
repeat on the other side



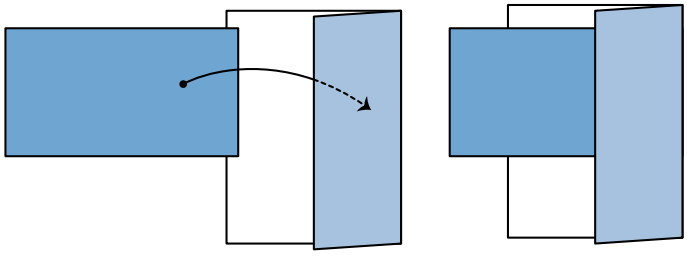
rotate 90° (or any other angle if specified)



turn paper over



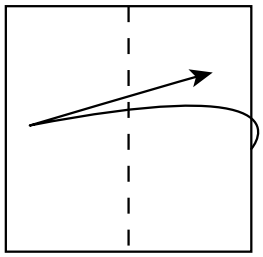
semi-fold (pre-crease)



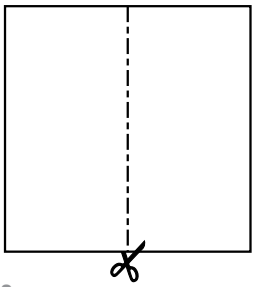
put inside

HOW TO CUT A...

1:2 RECTANGLE (HALF SQUARE)

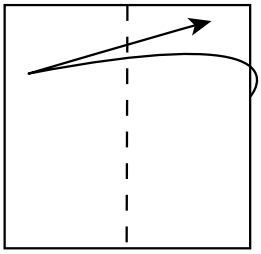


1



2

1:√3 RECTANGLE



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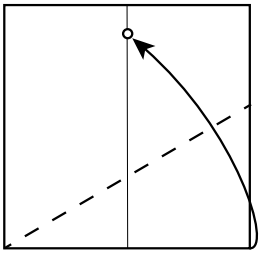

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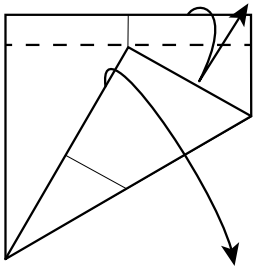

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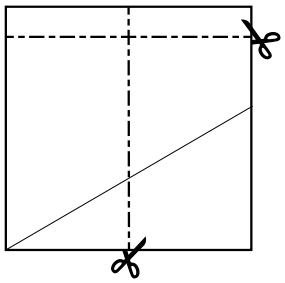

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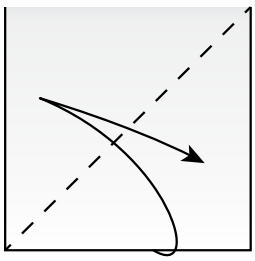
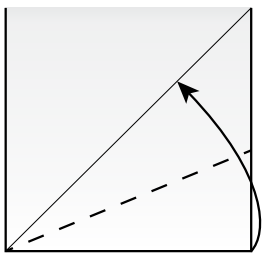
1:√2 RECTANGLE



1 start with square or rectangle



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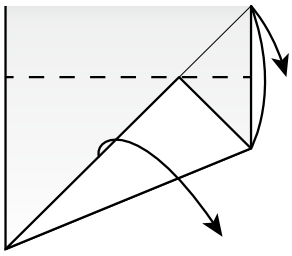

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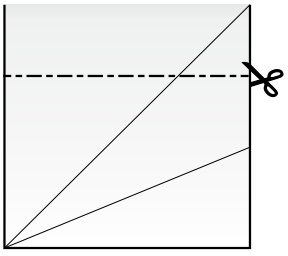
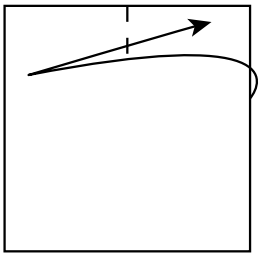


4 the lower rectangle has 1:√2 proportion

DIVISION INTO THIRDS



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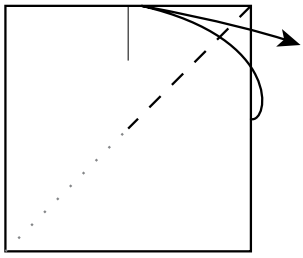

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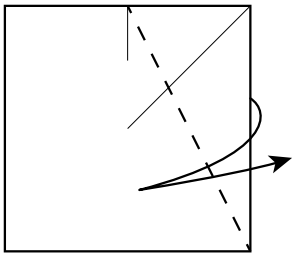

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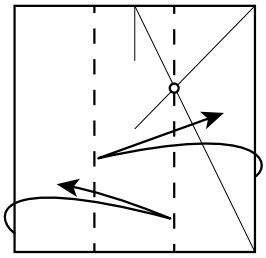
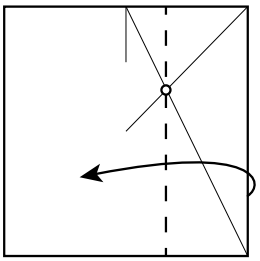


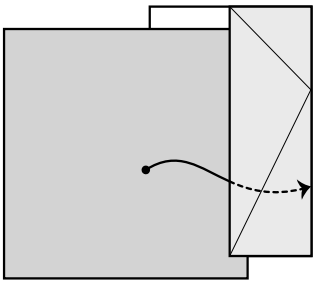
4 make the crease parallel to the side through the intersection, then make the second crease

USING A TEMPLATE

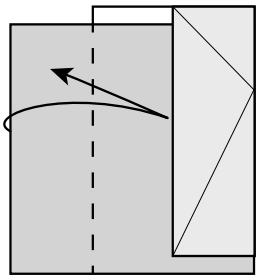
Use the following method to divide a square into thirds in order to save time and avoid unnecessary creases. Divide the first square into thirds by using the above method and use it as a template for the other units.



1 to make the template do steps 1-4 of the above method

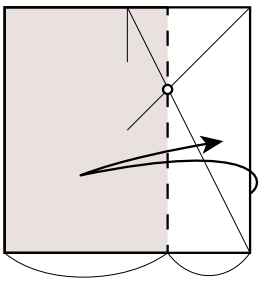


2 insert the other square of the same size till the end to the template

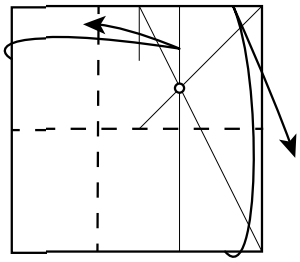


3 make the crease on the new square to the paper border; the new crease will be exactly 1/3 of the square

2:3 RECTANGLE



1 start with step 4 of dividing to thirds



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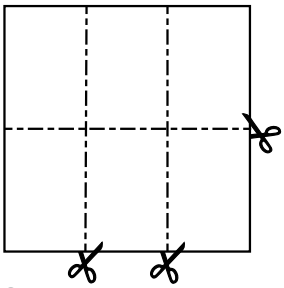


3

At step 1, the gray part is equal to 2/3 of the square's length, and the white part is equal to 1/3. If you want a large 2:3 rectangle, cut the white part away at this step and use the remaining gray area. If you wish to have smaller 2:3 rectangles, continue to steps 2-3.

MODULAR ORIGAMI

Origami is the art of paper folding. Traditional origami uses a single, uncut sheet of paper, whereas modular origami uses multiple sheets joined together to create a single form. This method offers great flexibility, while keeping the single unit relatively simple. So if you dislike 100+ step origami diagrams, but still want the resulting piece to look intricate, modular origami is for you.

The figures created through modular origami are usually highly symmetric, because they are made from multiple equivalent units, or modules. The origami modules usually have special locks to allow unit-to-unit connection without using any adhesive. This feature of modular origami brings it closer to construction sets: you are just making the pieces of the construction set yourself prior to the assembly process.

There are several names for modular origami throughout the world. In the West it is referred to as modular origami, but in Eastern Europe and South America, the Japanese word "kusudama" is commonly used for ball-like modular origami figures. In Japan, the word "kusudama" originally meant "medicine ball", possibly referring to a ball made from flowers and used for incense.

ABOUT THE AUTHOR

My name is Ekaterina Lukasheva, but my friends call me Kate. I became acquainted with modular origami as a teenager; it quickly became my passion and has been ever since. As I grew up, I continually developed my modular origami skills, and at some point I started creating my own designs. It is very interesting, since I compose the puzzles that I can then assemble into beautiful spheres. When I create a new origami model, I try to either make it look different from the existing models or make its modular locks different.

This book is my third published book. Kusudama Origami came out in 2014 followed by Modern Kusudama Origami in 2015. You can find more information about my other books on page 82. Besides, I usually publish my diagrams in various origami journals and convention books throughout the world. You can also find numerous kusudama pictures as well as a few free diagrams and videos on my website: www.kusudama.me.

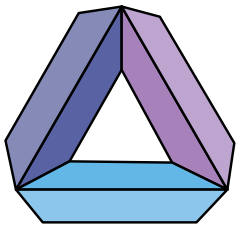
I was born in 1986 in Moscow, Russia. Since early childhood I was fond of architecture and design art books and catalogs, as well as "entertaining math" books. I tried several hobbies throughout my life such as construction sets, drawing, painting, photography, modeling and… origami. I am fascinated by the latter at the moment. For me it is the ultimate manifestation of mathematics, art and design. I gain inspiration from various 3-dimensional objects like flowers, cacti, architecture objects and stellated polyhedrons.

Even hold a M.Sc. in applied math and programming and a PhD in differential equations, I do not think background in mathematics is necessary to make and enjoy beautiful origami. ;)

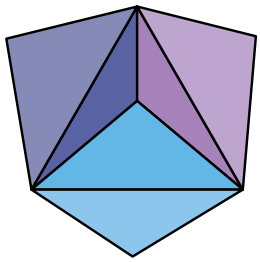
MODULAR ASSEMBLY

The units presented in this book can be assembled in various ways. The assembly methods for modular origami spheres are based on the structure of Platonic[1] and Archimedean[2] solids. Each unit corresponds to an edge of the solid. The detailed assembly of these solids is outlined below.

There are two types of units in this book: 'edge' units and 'solid' units. The former act and look like real edges of the solids when you assemble the modules. But indeed the 'solid' units act in the same way: the only difference is that the final shape becomes solid, and the holes between the units turn into pyramids.

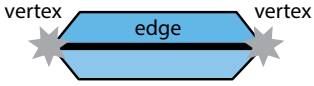


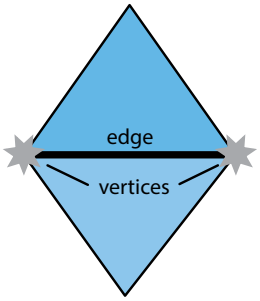
edge units



solid units

It means that the same assembly methods can be used for both 'types' of units. The following image illustrates the correspondence between units and the underlying solids.





The methods below will illustrate the assembly methods for the edge units. But the same assembly schemes apply to the solid units as well. The assembly schemes are given symbolically, each arrow represents the unit's particular connection method.

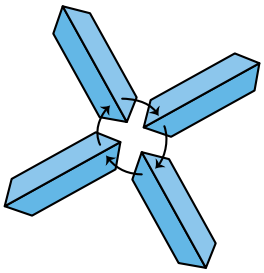
1 A Platonic solid is a regular convex polyhedron composed of identical regular polygons meeting at identical vertices.

2 An Archimedean solid is a highly symmetric, semi-regular convex polyhedron composed of two or more types of regular polygons meeting at identical vertices. They are distinct from the Platonic solids, which are composed of only one type of polygon meeting at identical vertices.

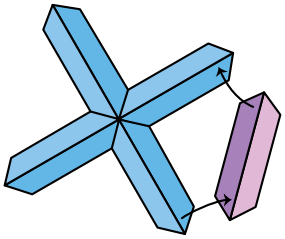
OCTAHEDRON

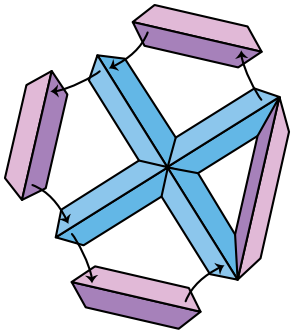
method 12A

A regular octahedron is a Platonic solid composed of 8 equilateral triangles, 4 of which meet at each vertex. Since an octahedron is formed with 12 edges, you will need 12 units to complete a modular octahedron figure.

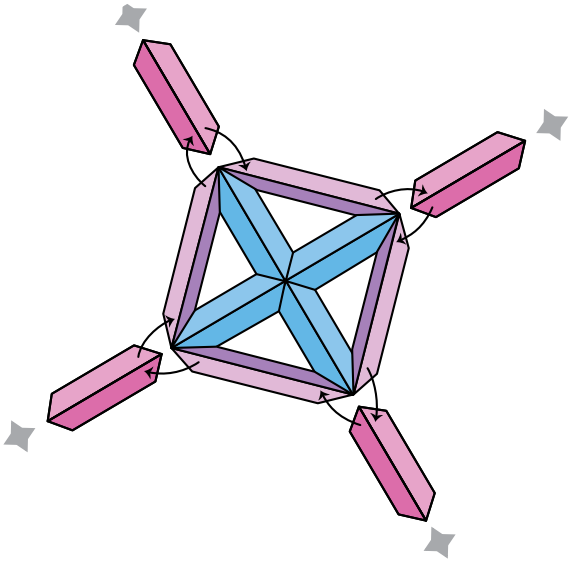


connect 4 units so that they meet at a single point



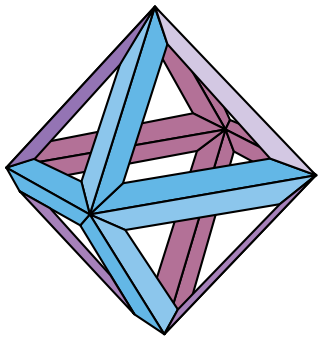


continue adding the units so that every 3 units form a triangular hole (triangular pyramid in case of solid units)

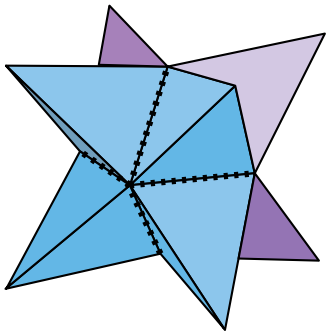


add 4 more units so that 4 units meet at a single point each time

connect the sides marked with the stars in the illustration to a single point behind, completing the octahedron



complete octahedron

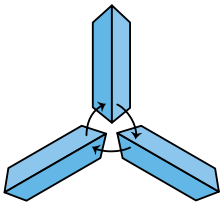


the solid version of the octahedron: the dotted lines show the underlying octahedron

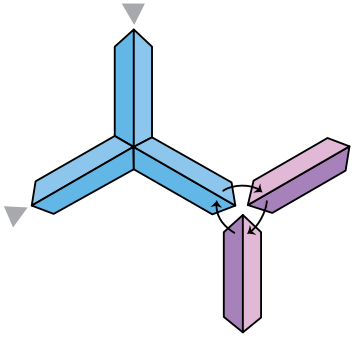
CUBE

method 12B

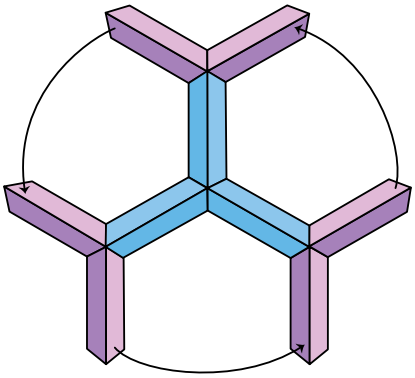
A regular cube is a Platonic solid composed of 6 square faces, with 3 edges meeting at each vertex. Since a cube is formed with 12 edges, you will need 12 units to complete a modular cube figure.



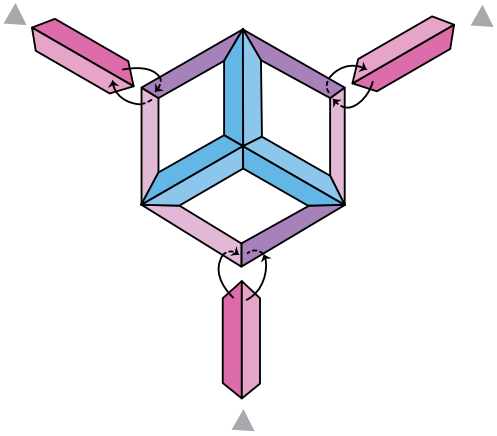
connect 3 units so that they meet at a single point



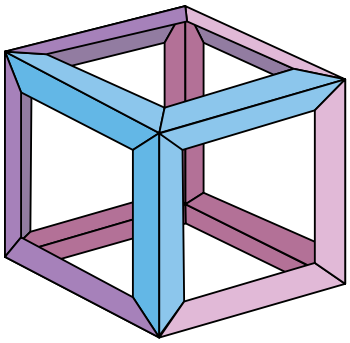
add units to the loose sides of the edges so that 3 units meet at a single point each time



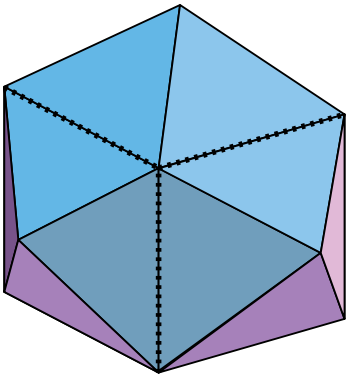
connect loose units as shown



add the remaining units so that 3 units meet at a single vertex, connect the sides of the units marked with triangles to a single point behind



complete cube

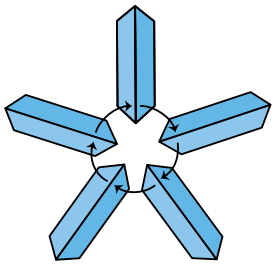


the solid version of the complete cube: the dotted line shows the underlying cube

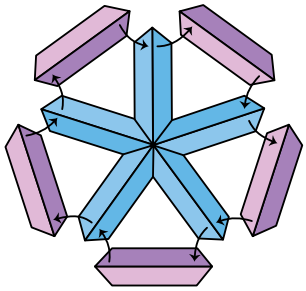
ICOSAHEDRON

method 30A

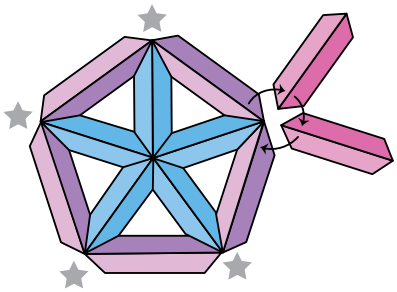
An icosahedron is a polyhedron composed of 20 triangular faces, with 5 of those meeting at each vertex. Since an icosahedron is formed with 30 edges, you will need 30 units to complete a modular icosahedron figure.



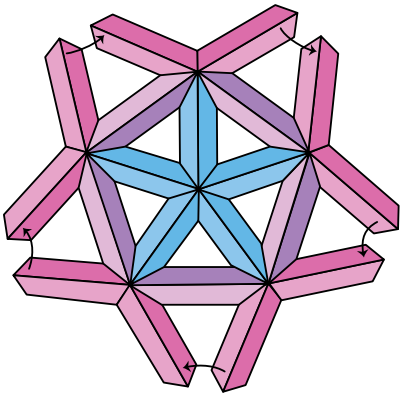
connect 5 units so that they meet at a single point



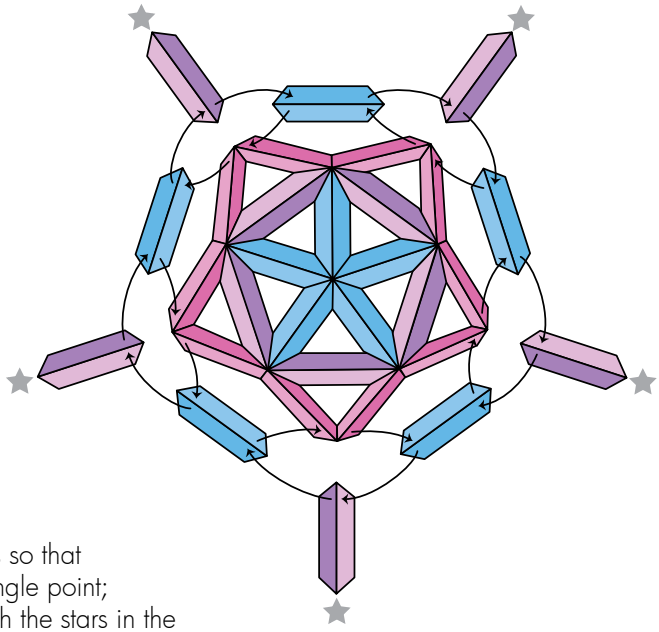
add 5 more units to form 5 triangles



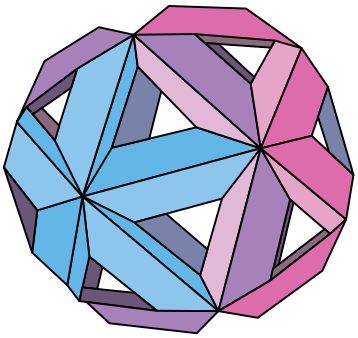
connect 2 additional units to every unfinished vertex, so that 5 units meet at a single vertex each time



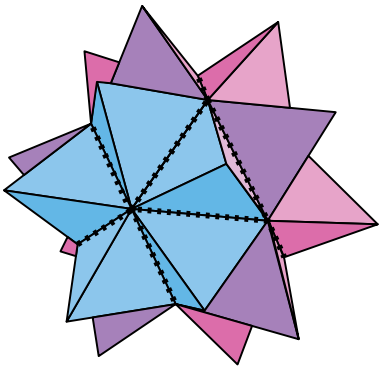
connect the loose sides of the units so that they form 5 triangles



add units to the non-finished vertices so that 5 units meet at a single point; the units marked with the stars in the picture should meet at a single point



the complete icosahedron (left) and the solid version of the icosahedron (right)

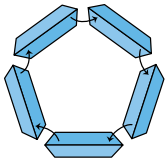


the size of the holes, as well as the sharpness of the spikes, may vary from unit to unit

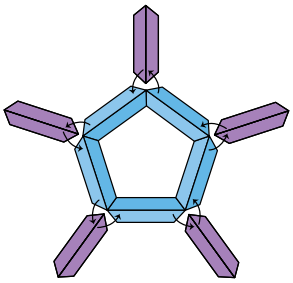
DODECAHEDRON

method 30B

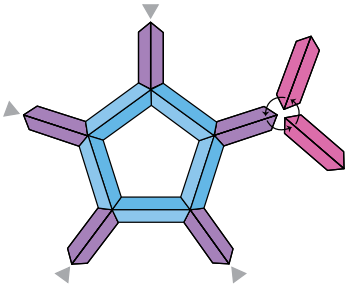
A dodecahedron is a Platonic solid composed of 12 pentagonal faces, with 3 of those meeting at each vertex. Since a dodecahedron is formed with 30 edges, you will need 30 units to complete a modular dodecahedron figure. The assembly scheme described below may not be the most comfortable; while it illustrates the algorithm, the actual sequence of the assembly may be slightly different.



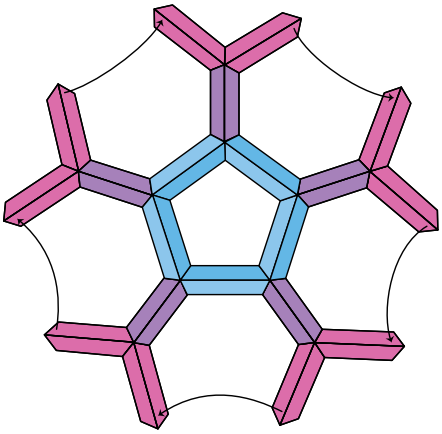
connect 5 units so that they form a ring



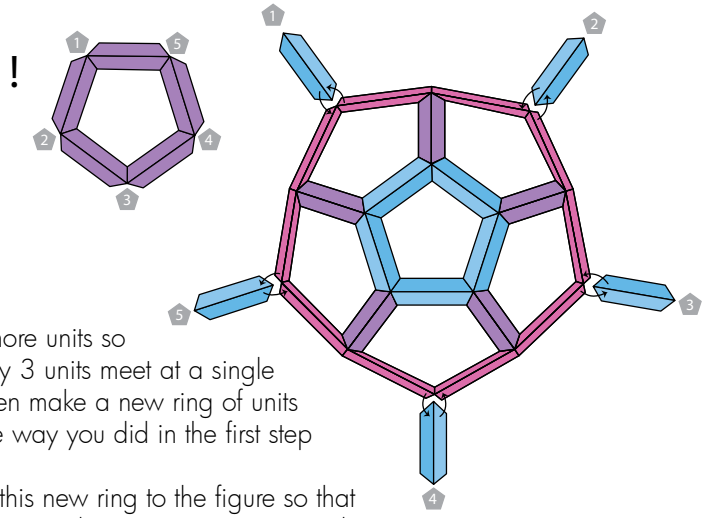
connect 5 more units so that every 3 units meet at a single vertex as shown



add 2 units to every loose side of the unit so that 3 units meet at every point



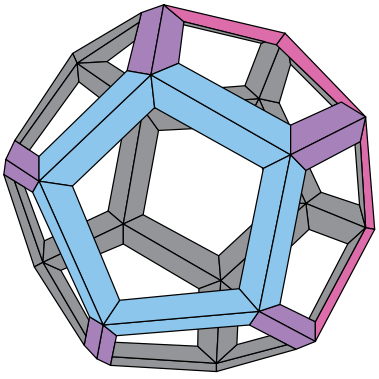
connect the loose edges so that you get 5 pentagonal rings around the central one

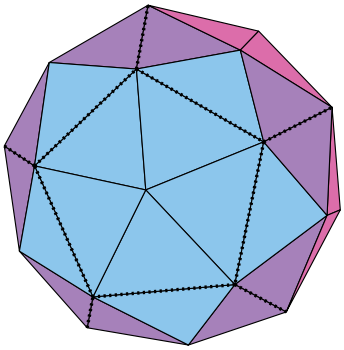


add 5 more units so that every 3 units meet at a single point, then make a new ring of units the same way you did in the first step

connect this new ring to the figure so that the numbers in the grey pentagons match up

this picture is to illustrate the structure only, as it is easier to add the last 5 units one by one



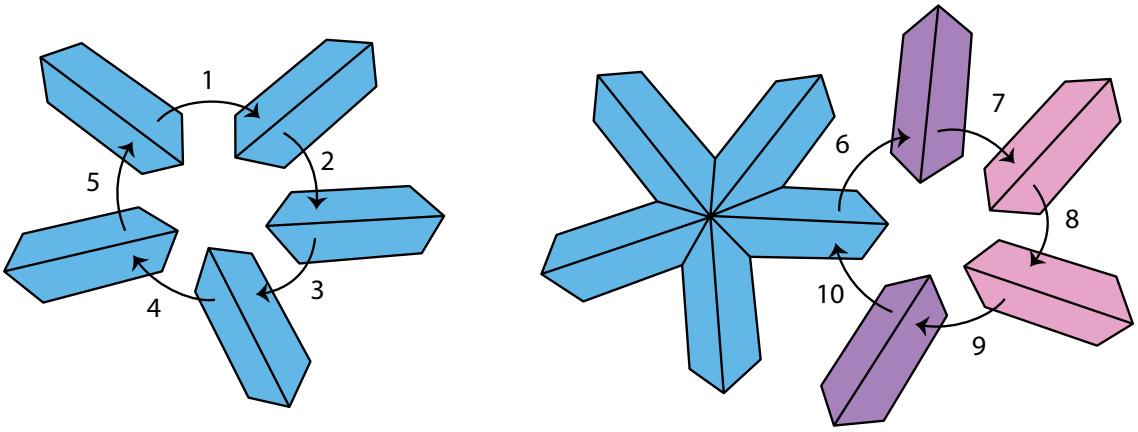


the complete dodecahedron (left) and the solid version of dodecahedron (right)

the size of the holes as well as the sharpness of the spikes may vary from unit to unit

ASSEMBLY HINT

Some of the models in this book share a similar connection system which can look unstable at first glance. However, if you join the pieces as shown below, they will connect more stable, and assembly process will be more comfortable. The diagram below illustrates the modified assembly sequence for the icosahedron (30A method), but the same idea may be applied to any sphere you assemble. The concept behind this method is to try and finish the vertices of the polyhedron first. Thus, when you assemble an icosahedron, finish the vertices where five edges are connected. Since a "star" of five units is enclosed it becomes stable (steps 1-5 in the picture). Instead of closing the adjacent triangles, you should then assemble the next "star" (steps 6-10). Continue to assemble the model by finishing the vertices, proceeding in this fashion until the model is finished. As you go, keep in mind that the holes between the units should be triangular.



TIPS AND TRICKS

- Try to choose papers of the same type and weight for a single model. If you mix papers with different properties in a single model it may not only look inconsistent but may also lack symmetry.
- Try folding a test unit from lager piece of paper before starting the entire modular. It may give you a hint as to what paper size would be most comfortable for you, as well as how the color or pattern of the paper will appear when folded into a particular module.
- If you are not sure how to perform a particular step, refer to the next step in the diagram, as the illustration should give you a hint of the resulting shape.
- If you would like to use sticky notes for folding , you can apply some corn-starch directly on the adhesive, making it less sticky and more ideal for folding.
- Be as accurate as possible when making every single unit. The more precise you are, the better the final model will look. Some modular locks only function when your folding is very precise.

For precise and sharper creases use a folder or a wooden stick. You may find a special origami folder or use some clay modeling tools you can find in any art supply store.

A pincer or tweezers can be very handy during the assembly process or for curling the petals. Use it when you need to tuck the small flaps into pockets.

Paper and craft knives can be used for cutting paper.

A letter opener can be very useful for cutting paper when you travel; you can take it even on board!

PVA glue

Clips can be helpful to temporarily fasten the units for stability during the assembly.

The models in the book do not generally require glue for assembly, but if you are a novice to modular origami you may need some. If you want your kusudama have a better chance of staying together when handled by guests, children or gently batted by animals, add a bit or glue during assembly or to a complete model. Stick glue is better during assembly, while PVA glue (white liquid glue) can be used to fasten more permanently the complete model. Add a drop of PVA glue to the point where units meet to fasten the point. This glue becomes nearly invisible when dry, but be sure to test it on a scrap of your selected paper before adding to the kusudama.

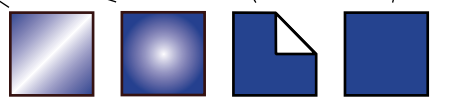
Near the model name for each diagram in this book, you will find some symbols and other indicators with suggestions to help guide you in your paper selection, as well as the difficulty level and assembly possibilities for a particular model.

Suggests the use of origami-specific gradient paper: there are several types of different patterns, specific pattern can enhance model a lot.

Suggests the use of paper with different colors on each side.

The other side of the paper won't be seen.

Difficulty level out of 5.



☆☆

30A, 12A

Recommended assembly method and number of units (see pages 12-15).

7x7 cm square

Recommended paper size (novices may want to use larger paper, whereas experienced folders could go even smaller).

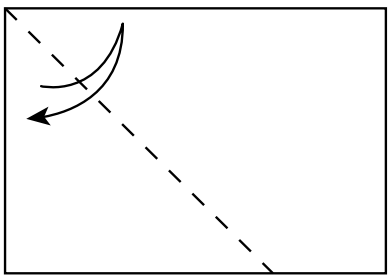
MODEL NAME

☆☆
5 units

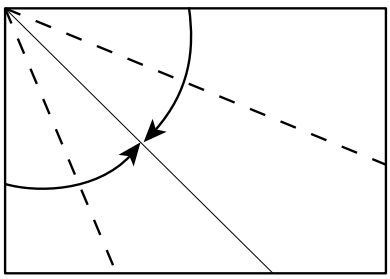
5 x 7.1 cm rectangle (proportion 1:√2 (1:1.41))

FLOWER STAR

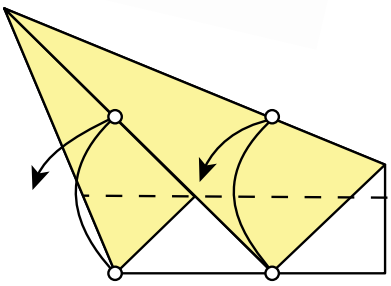
This is a good starting model, because it only requires 5 units to form a star. You can use cutting instructions from the beginning of the book or use European letter paper (which has the same 1:√2 proportion) and divide it into 16 equal rectangles.



1 start with 1:√2 rectangle,
see page 8 for cutting instructions



2

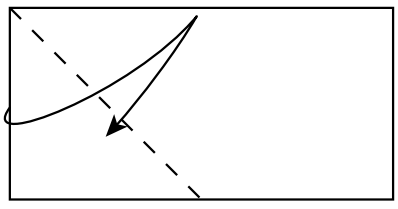


3 fold aligning the points

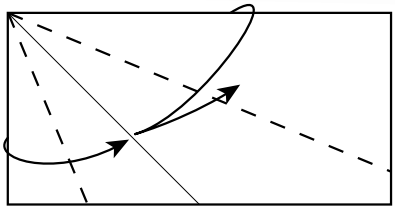
☆☆
4-6 units

5 x 10 cm rectangle (proportion 1:2)

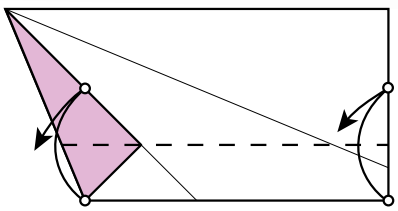
DELICATE FLOWER



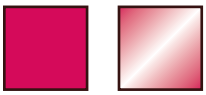
1 start with 1:2 rectangle,
see page 8 for cutting instructions



2



3 fold aligning the points



☆☆

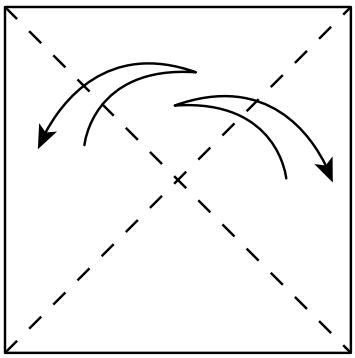
30A, 12A

7 x 7 cm square

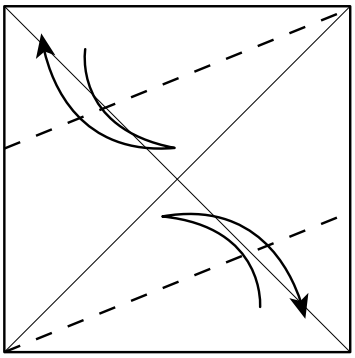
ALMANDINE

This model can have two different faces. If you choose harmony paper, you can accent the flower-like petals. If you chose monotone paper, you will emphasize the unusual geometry of this model.

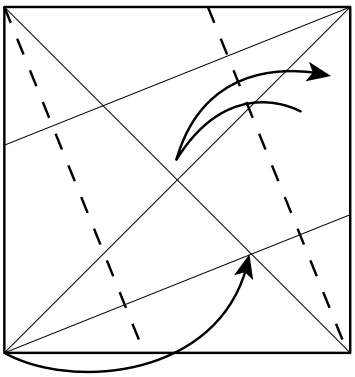
30A



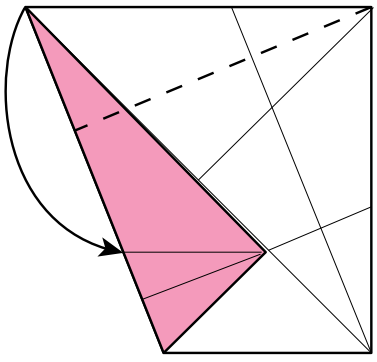
1



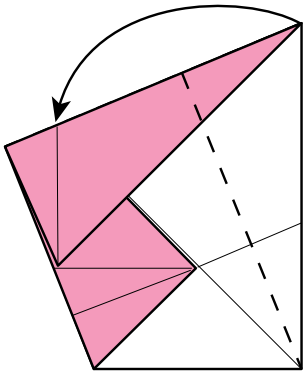
2



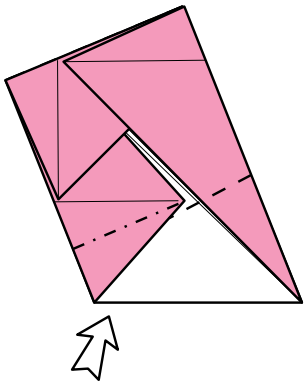
3



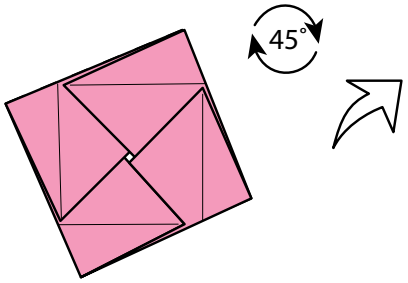
4



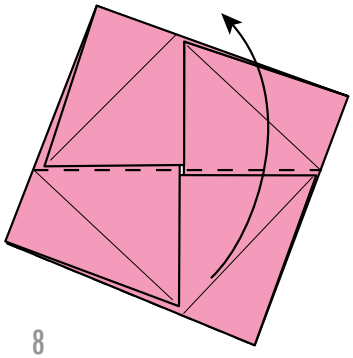
5



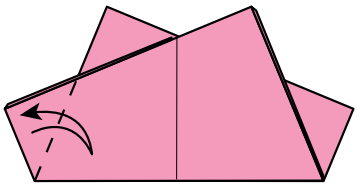
6 inside reverse fold



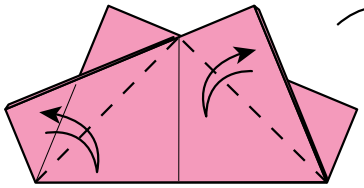
7



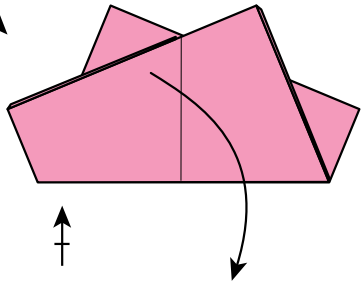
8



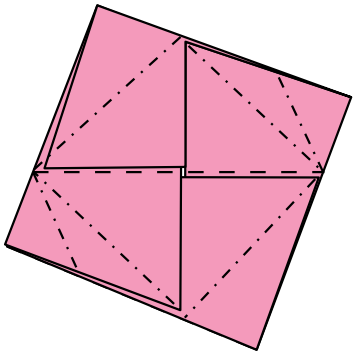
9



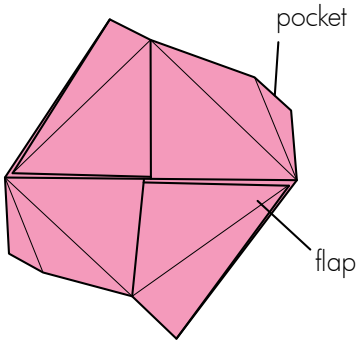
10



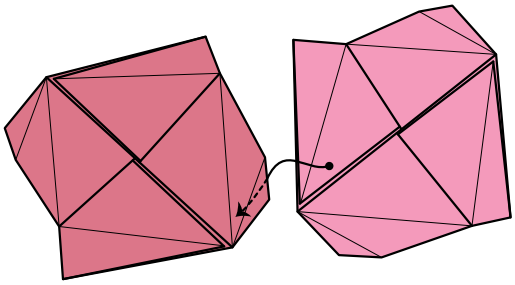
11 repeat steps 9-10 and unfold



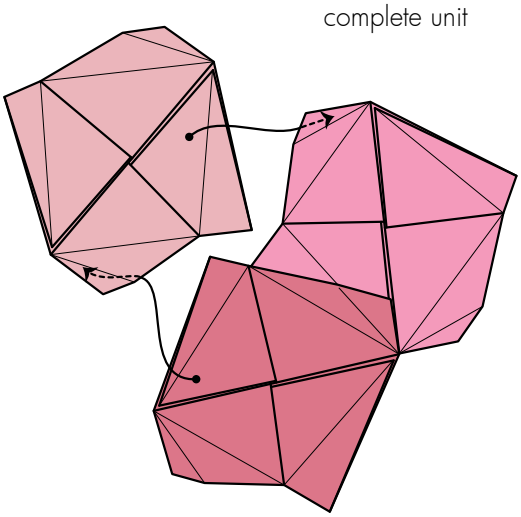
12 semi-fold along the marked lines



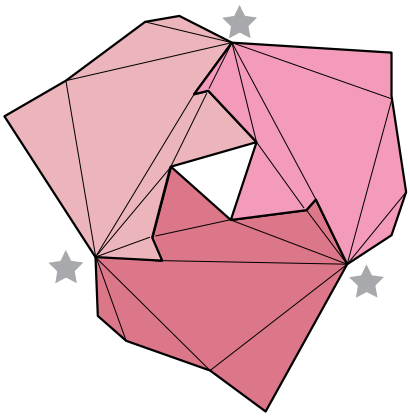
complete unit



to connect the units slide the flap into the pocket



2 connected units: add the 3rd unit to make a triangular pyramid with the hole in the center
if you're having trouble, see the next picture



3 connected units
use assembly method 30A on page 14
or assembly method 12A on page 12

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To contact me use art@kusudama.me