A STEM Project: Rubber Band Polyhedron Pop-ups - Bifrustums and Bicupolas

Rubber Band Polyhedron Pop-ups - Bifrustums and Bicupolas

Rubber band polyhedron pop-ups in action

Rubber band pop-up polyhedrons are intriguing. They are the intersection of mathematics and physics. The process of compressing the figure stores energy in the rubber band inside the figure. When the collapsed two dimensional shape is allowed to be transformed back into a polyhedron, the stored energy makes the figure pop-up. These pop-ups are a fun way to explore mathematics and physics together.

Bifrustums and bicupolas are names given for different types of polyhedrons. For more information about them, http://www.interocitors.com/polyhedra/Triamonds/

Materials needed to make the pop-ups:

- 65 lb. card stock which can be found at your local craft store in a variety of colors.

- Aleene's Tacky Glue. I recommend this glue as it is a quick drying glue which does not warp the paper when used sparingly. I fill a quilling bottle with this glue to get an extra fine point. This is not necessary for this model but I thought I should mention it. If you look at my photos, you will see the extra fine dots of glue.

- Glue Dots. I used 3/8 in. Glue Dots rolled into a ball and attached to the tail of the rubber band so that the rubber band does not slip out of the hole with repeated opening and closing of the model.

- Scotch Tape to anchor the rubber band with the Glue Dot down to the tab.

- 1/16 inch rubber bands. Please note that different rubber bands may have different tensions. The length that I am giving for each model is just a guide. When making knots in the rubber band, don't pull the knots too tight because the knot acts like a stopper in the hole.

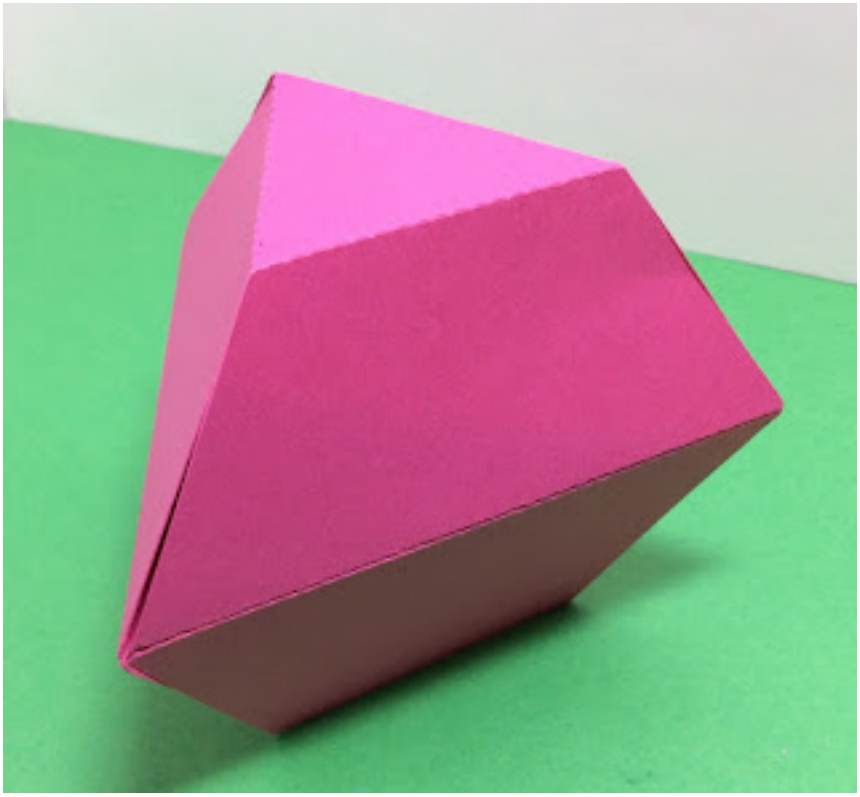
- Scissors or an electronic paper cutter like a Silhouette or Cricut.

If you are cutting the models with scissors, here is the PDF:
https://drive.google.com/file/d/17wFgYkhh5gj6OWmYZWpUPRq59wXCHgXv/view?usp=sharing

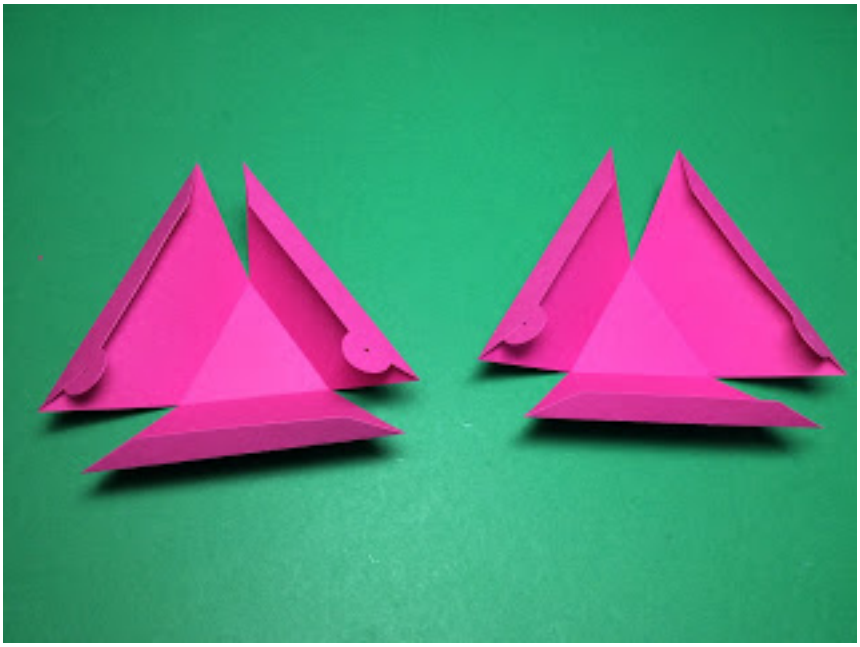
If you are cutting the models with a Silhouette, here is the .Studio file:
https://drive.google.com/file/d/1MDmdcO2rhjzKv3orqe7B0MWs1uza6BnF/view?usp=sharing

If you are cutting the models with a Cricut, here is the SVG:
https://drive.google.com/file/d/1iR-Ih3OV_e1kz1HU-AIVSGz6wsYvuR-3/view?usp=sharing

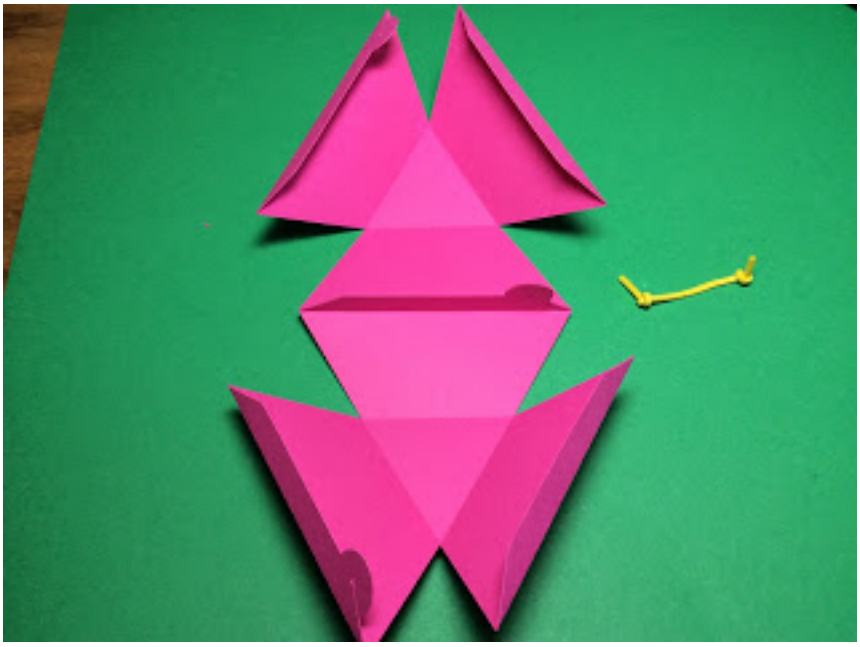
1. Triagular Bifrustum	
Faces	6 trapezoids, 2 triangles
Edges	15
Vertices	9



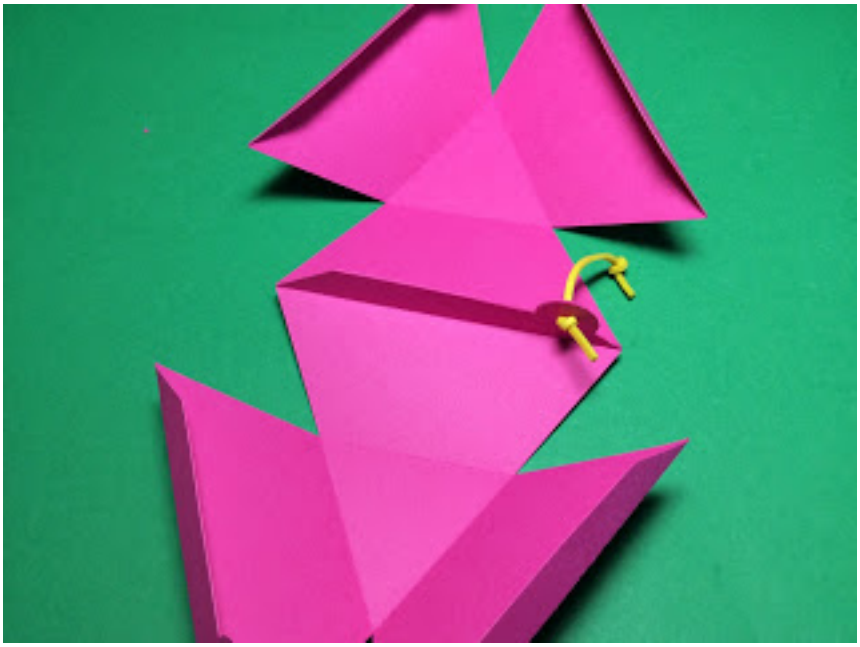
Triangular Bifrustum - Notice in the photo above, it looks like a triangular pyramid without its top. The word frustrum means it is a section of an original solid. There are two of these frustums attached. "Bi" means two so that is how it got its name of triangular bifrustum.



Cut out the triangular bifrustum model. Bend the tabs on each section as shown above.

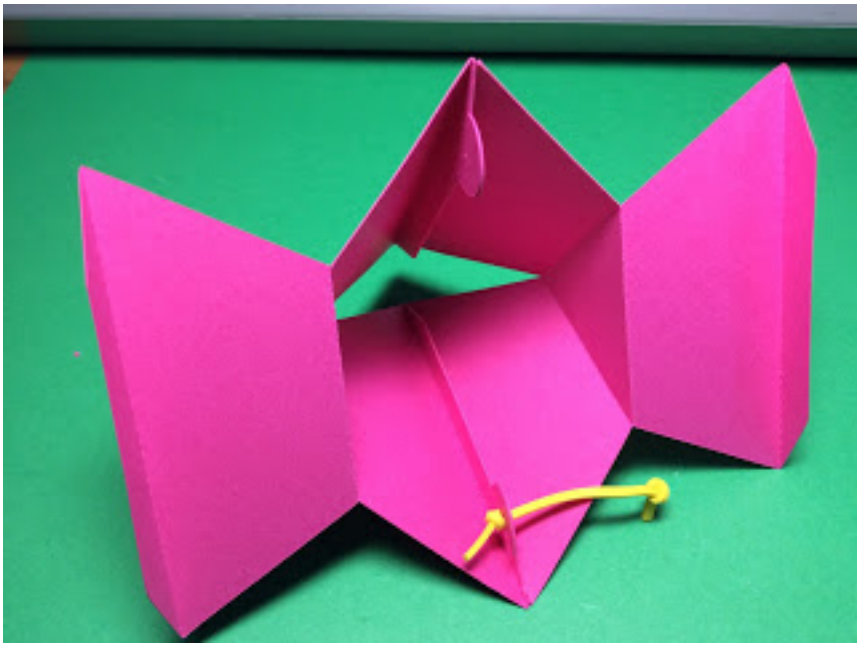


Cut and knot a rubber band that is approximately 1 inches long between the knots. Align the two sections together, making sure that all of the tabs align correctly. Glue one of the tabs with the circle together as shown above.



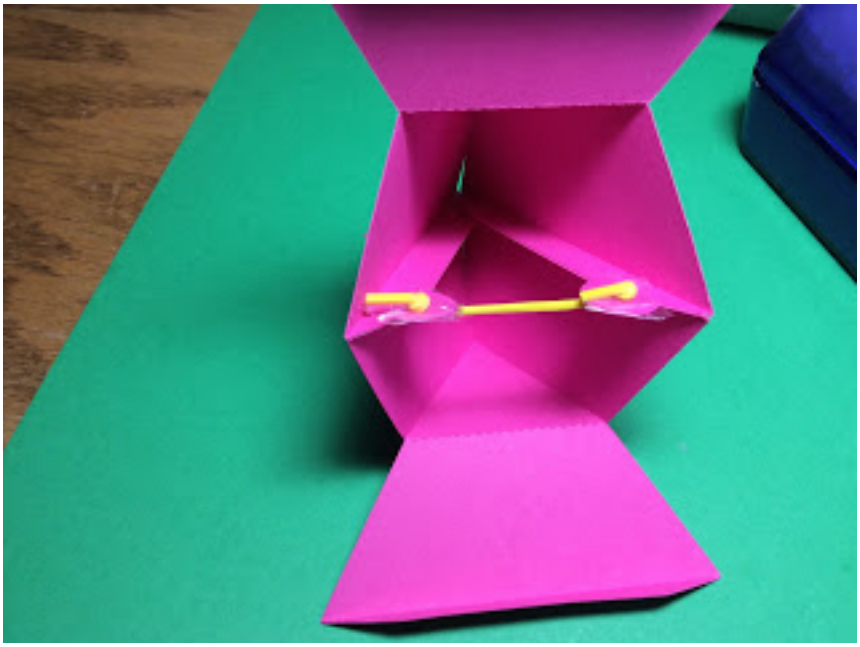
Insert and align the rubber band into the hole.

Apply glue to the other tab with the circle.

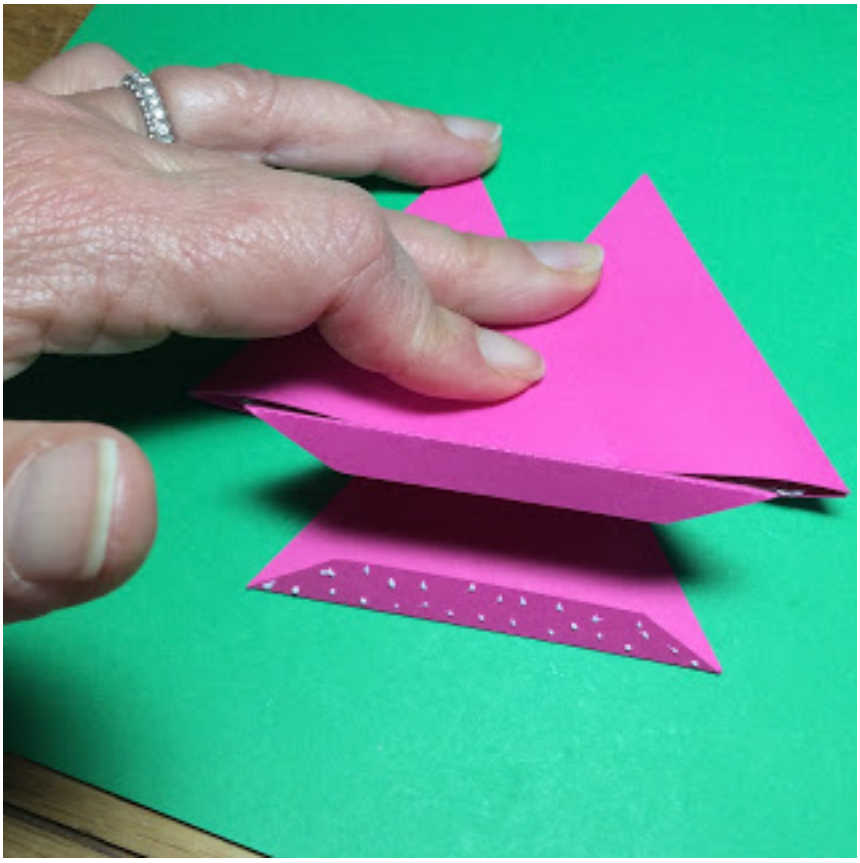


Adhere the corresponding tab. Apply a Glue Dot to the tail of the rubber band.

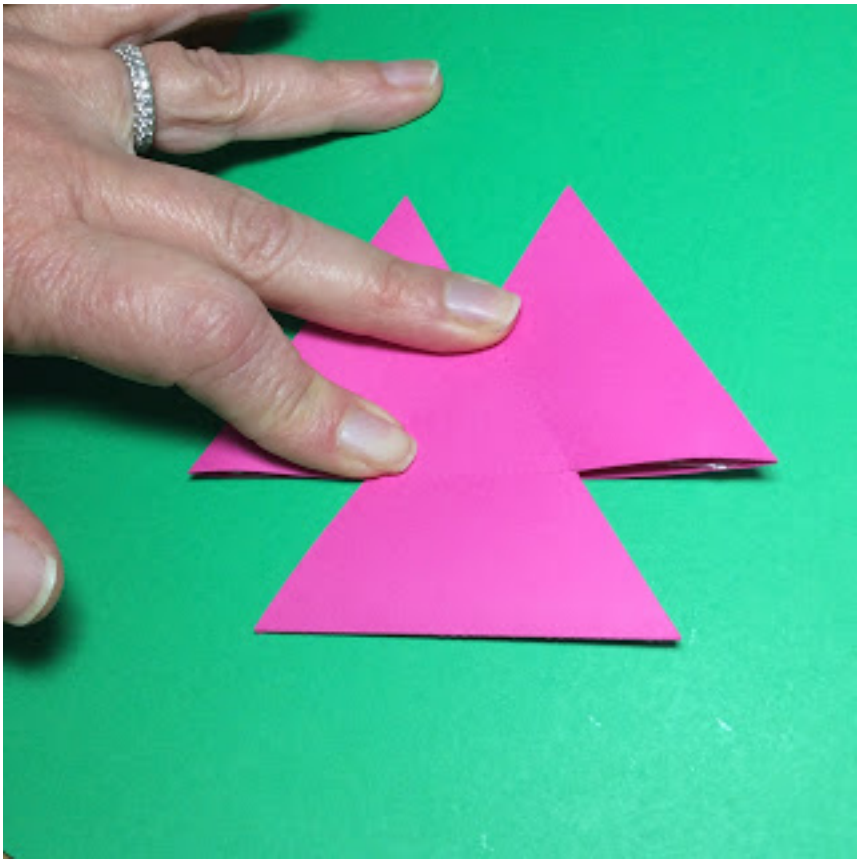
Apply a piece of tape to cover the Glue Dot and rubber band tail. I am showing a little piece of tape on the tape dispenser. This is the size of tape that I used to cover the tail and Glue Dot.



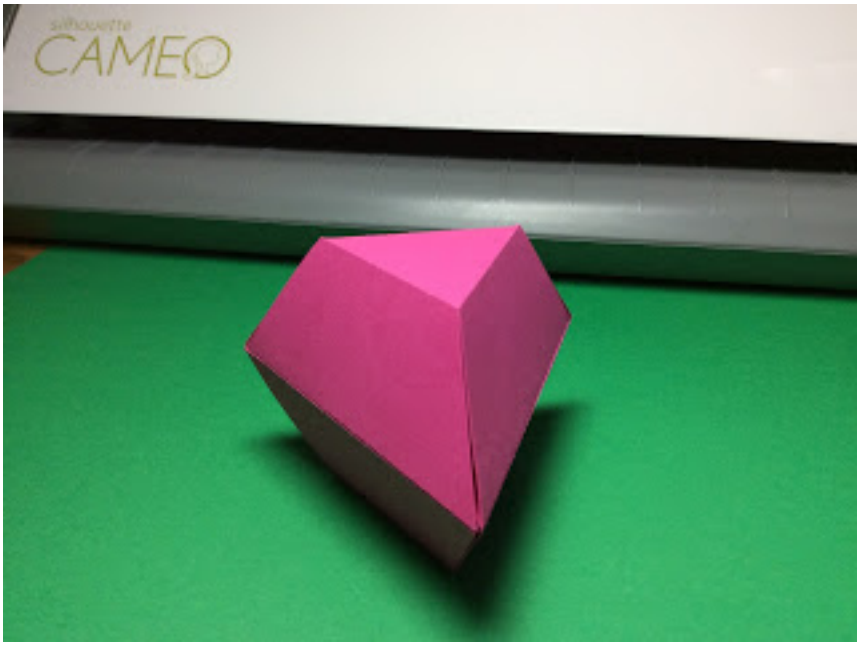
Insert and align the rubber band into the other hole. Apply a Glue Dots and tape to the rubber band tail.



Apply glue to one of the remaining tabs. Collapse the shape.

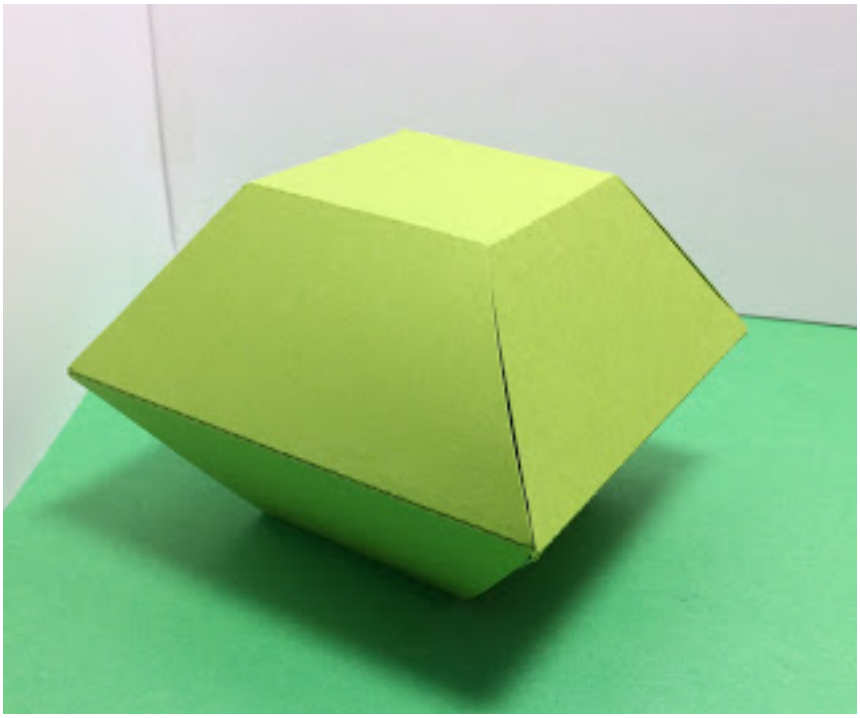


Apply pressure to this tab to adhere the glue.

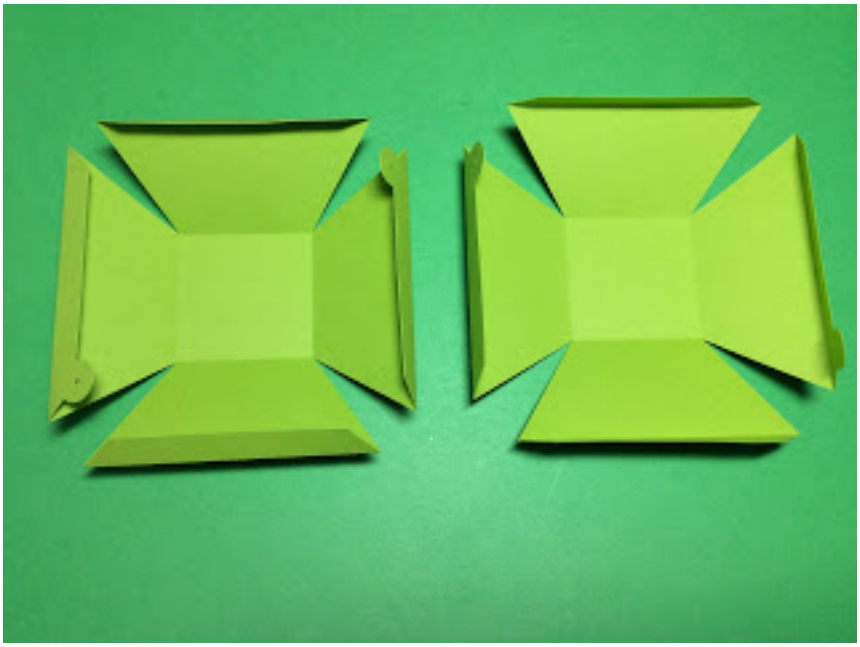


Completed Triangular Bifrustum

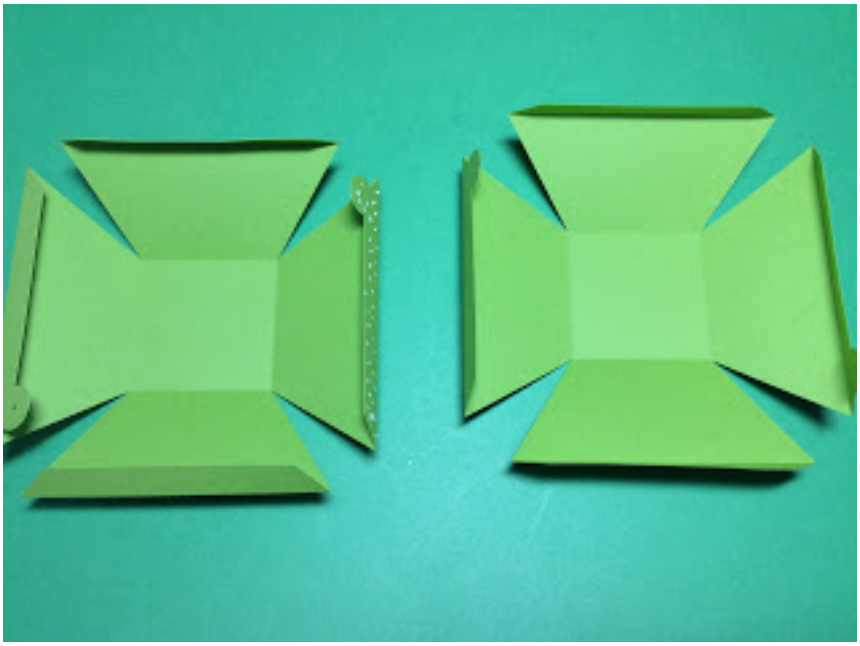
2. Square Bifrustum	
Faces	8 trapezoids, 2 squares
Edges	20
Vertices	12



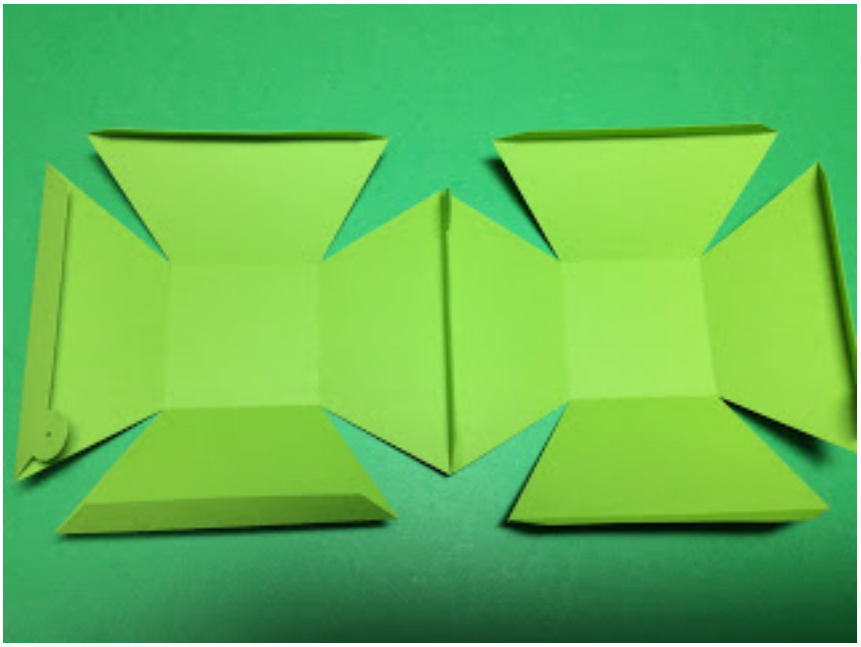
Square Bifrustum



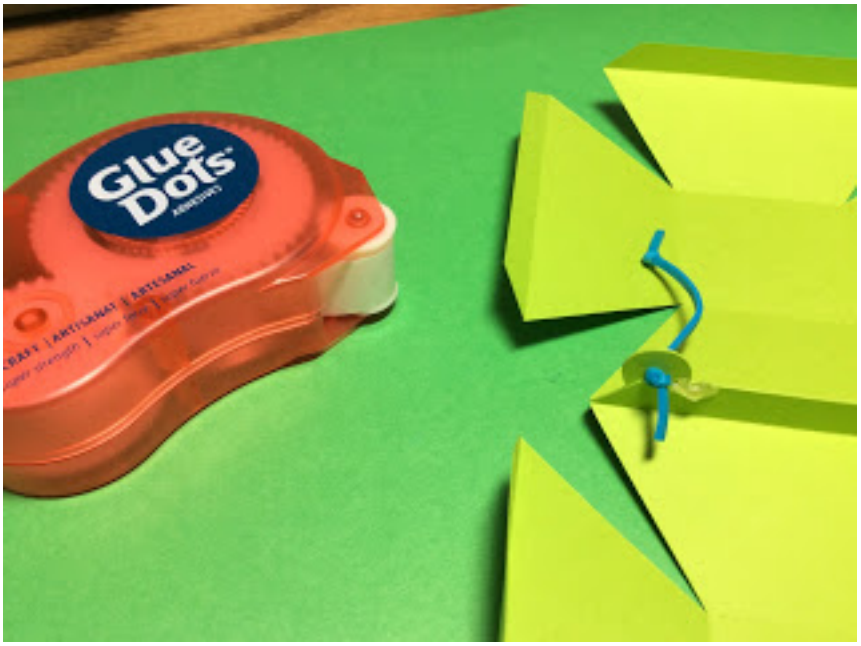
Cut out the triangular bifrustum model. Bend the tabs on each section as shown above.



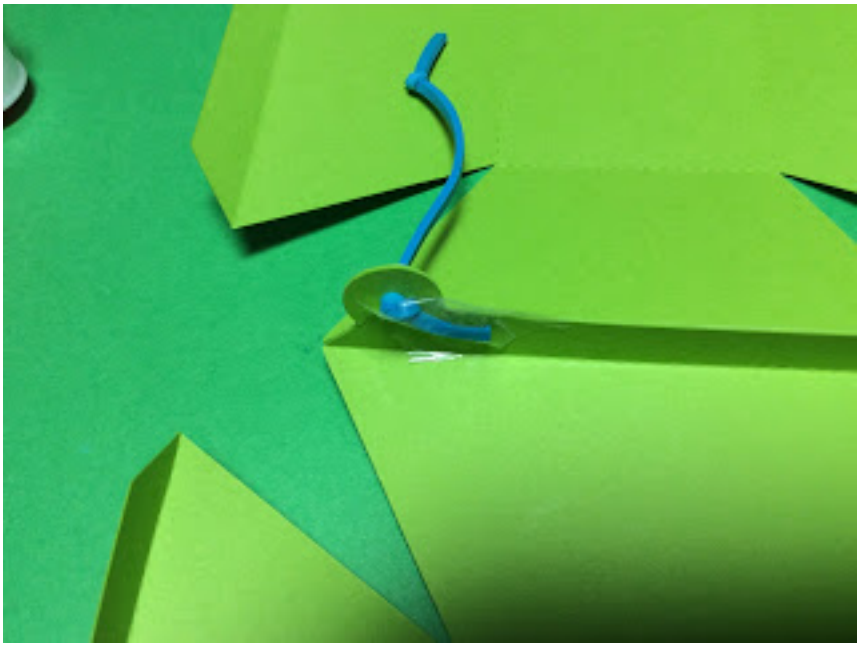
Apply glue to the tab with a circle.



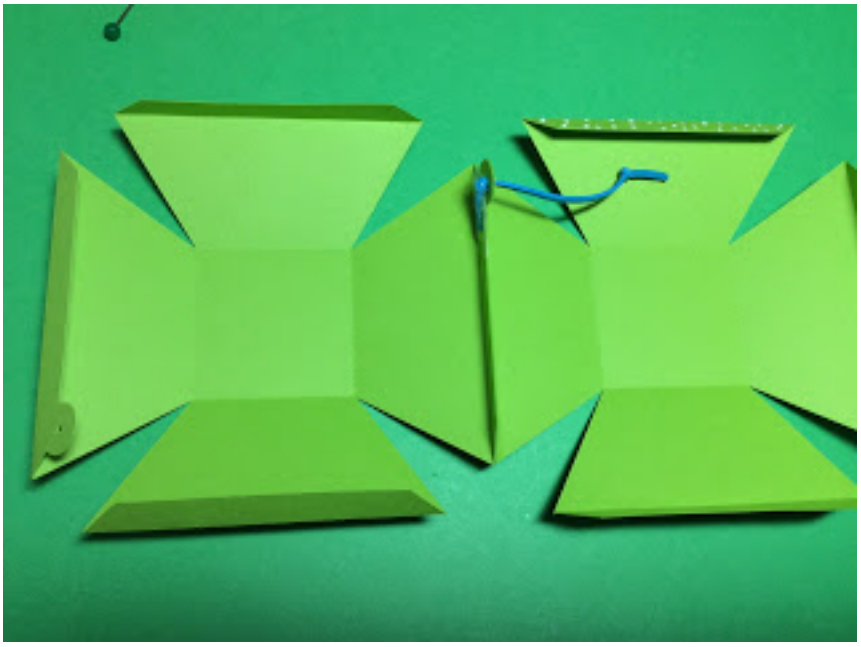
Adhere it to the corresponding tab.



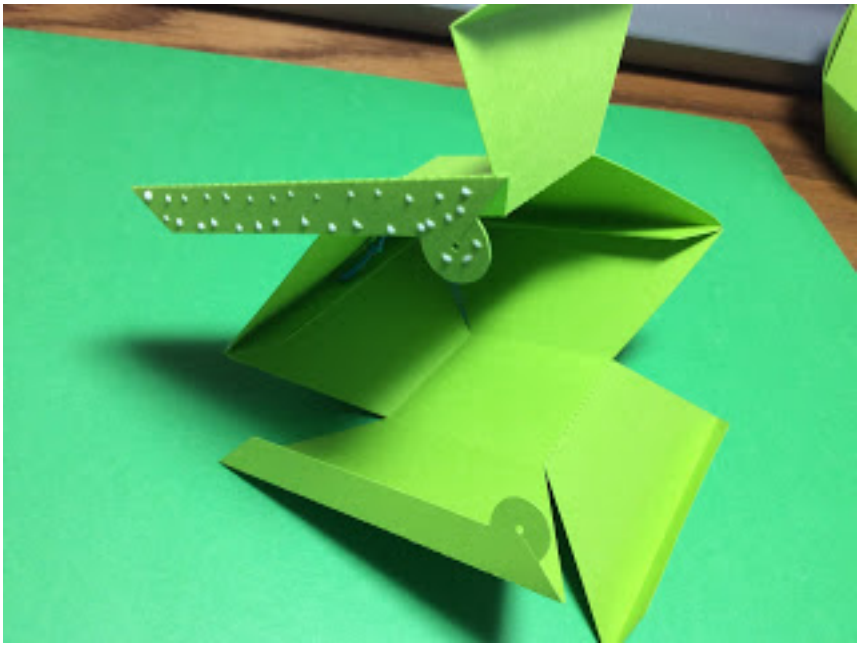
Cut and knot a rubber band that is approximately 1.75 inches long between the knots. Slide the knot into the slit. Apply a Glue Dot to the tail of the rubber band.



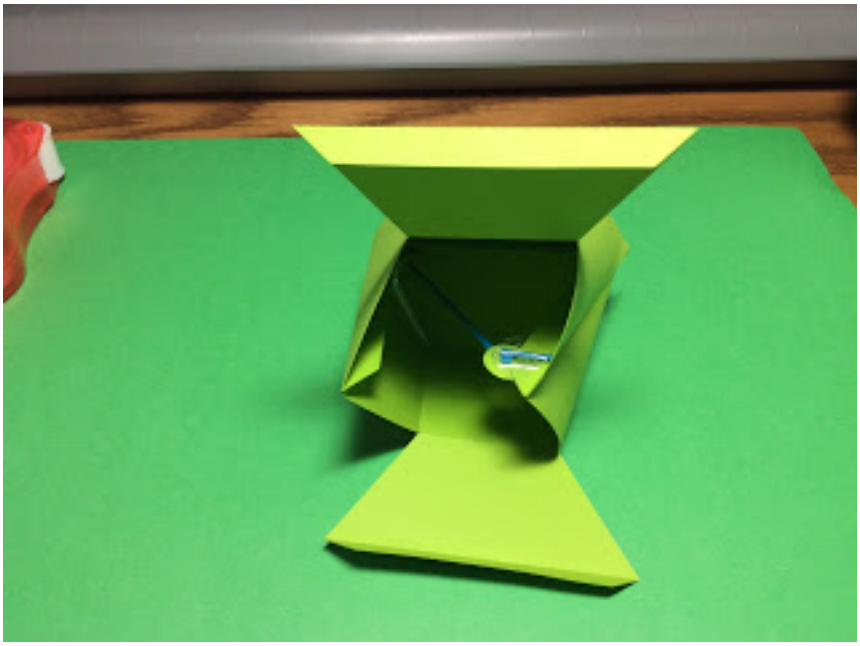
Apply a piece of tape over the Glue Dot and tail of the knot.



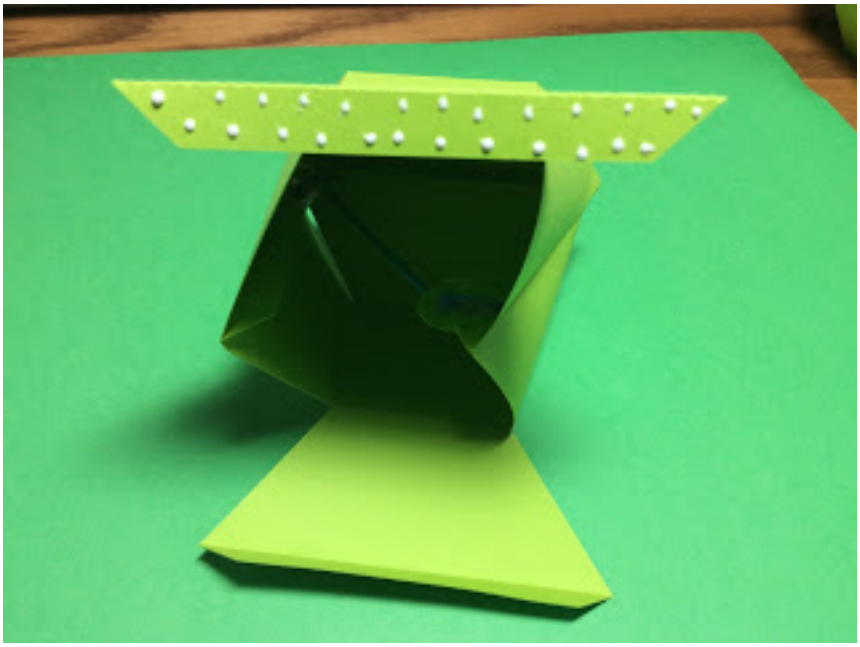
Apply glue to the tab at the top. Adhere it to the corresponding tab by folding it in half.



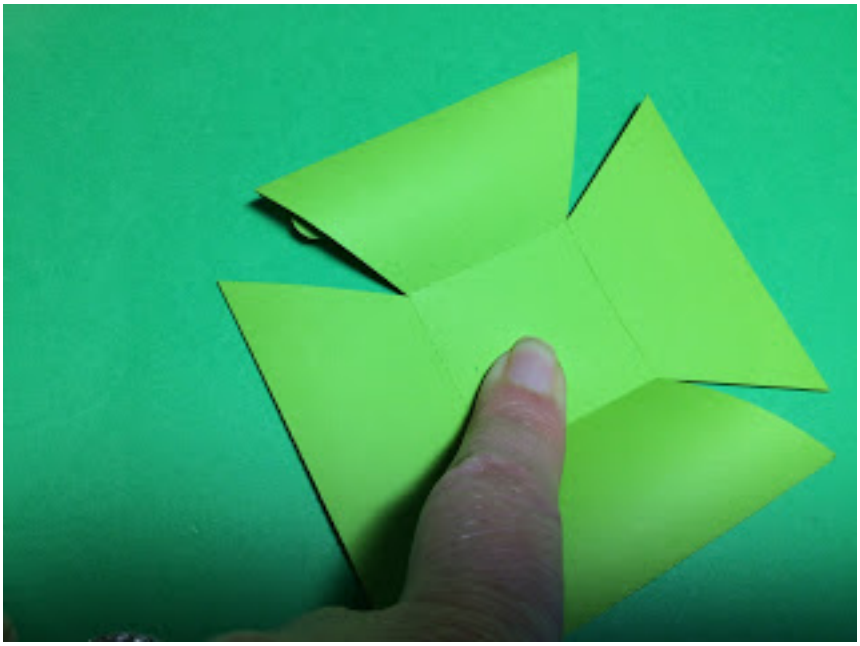
Apply glue to the tab with a circle.



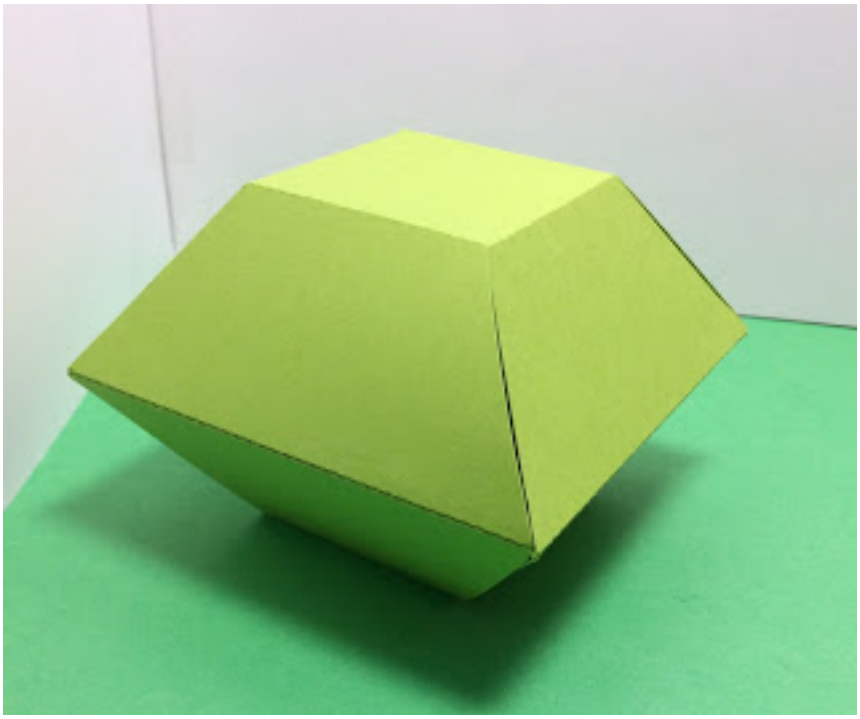
Slide the rubber band onto the slit. Apply a Glue Dot to the tail of the rubber band. Apply a piece of tape over the Glue Dot and tail of the knot.



Apply glue to the remaining tab.

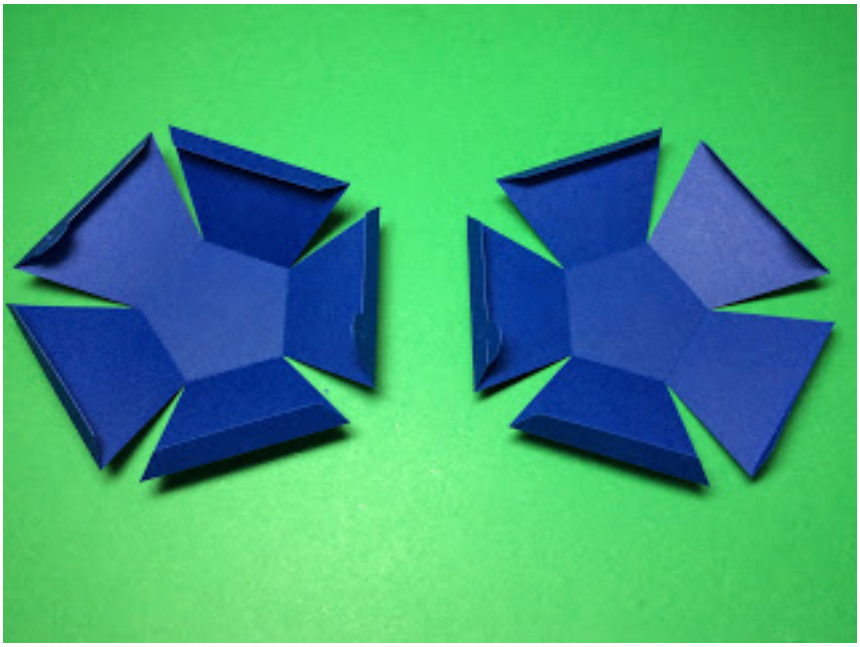


Compress the model and adhere this tab.

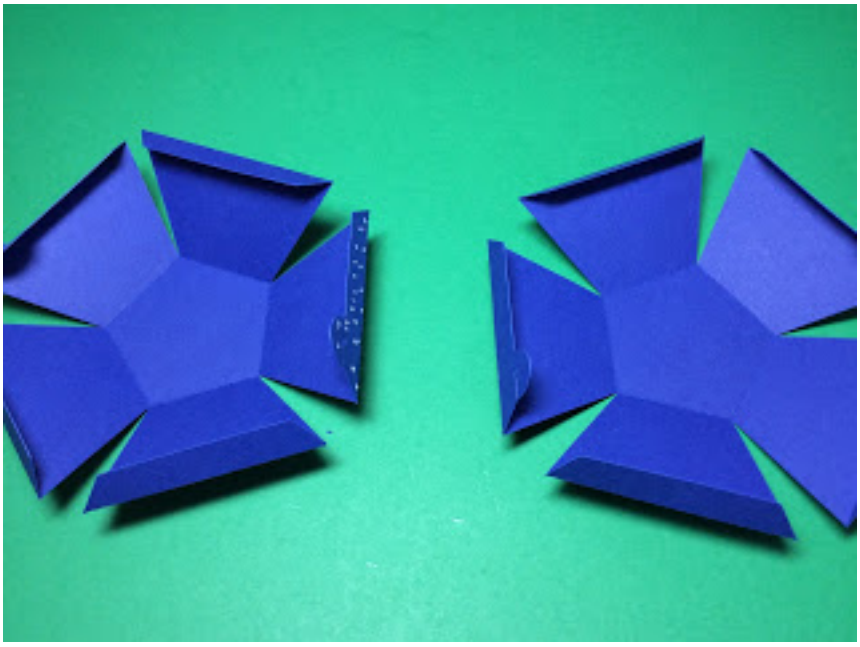


Completed Square Bifrustum

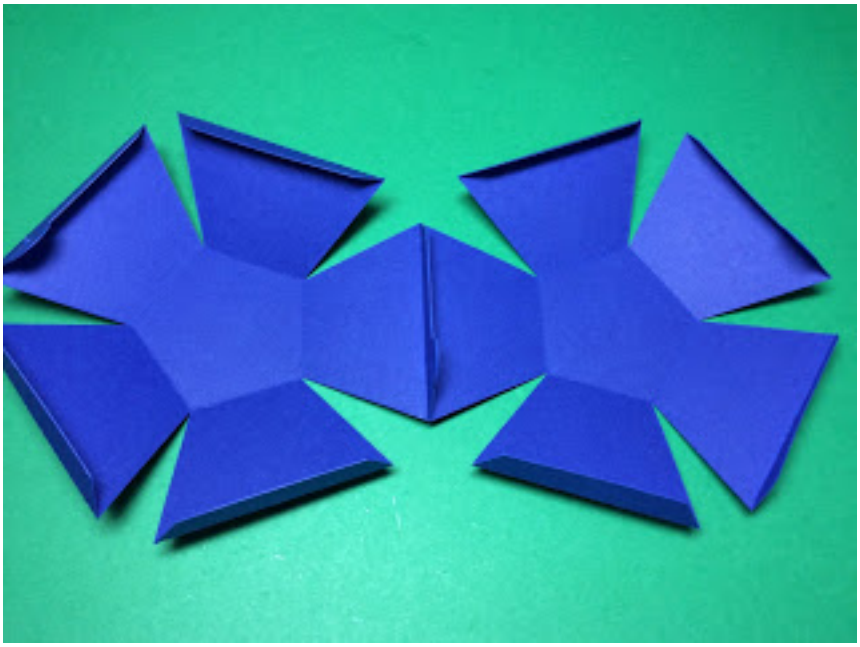
3. Pentagonal Bifrustum	
Faces	10 trapezoids, 2 pentagons
Edges	25
Vertices	15



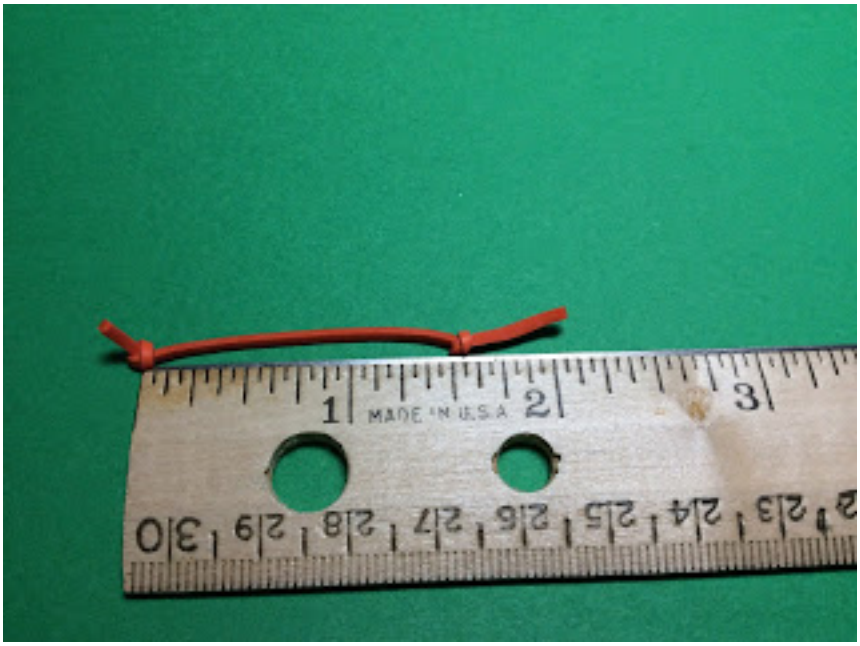
Bend the tabs on each section as shown above.



Apply glue to one of the tabs with a circle. Make sure that the two sections will align correctly with the corresponding tabs.

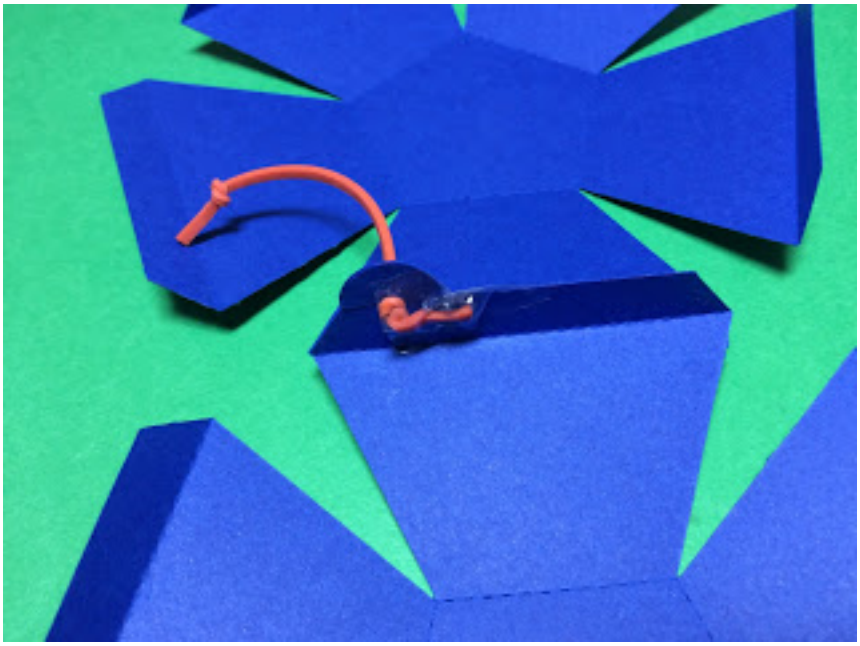


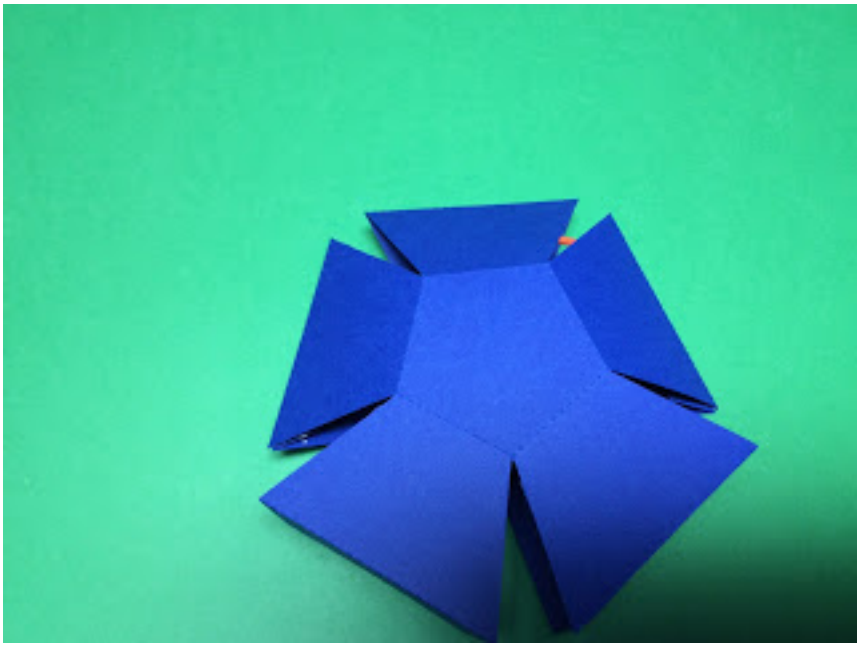
Adhere the tabs together



Cut and knot a rubber band that is approximately 1.5 inches long between the knots.

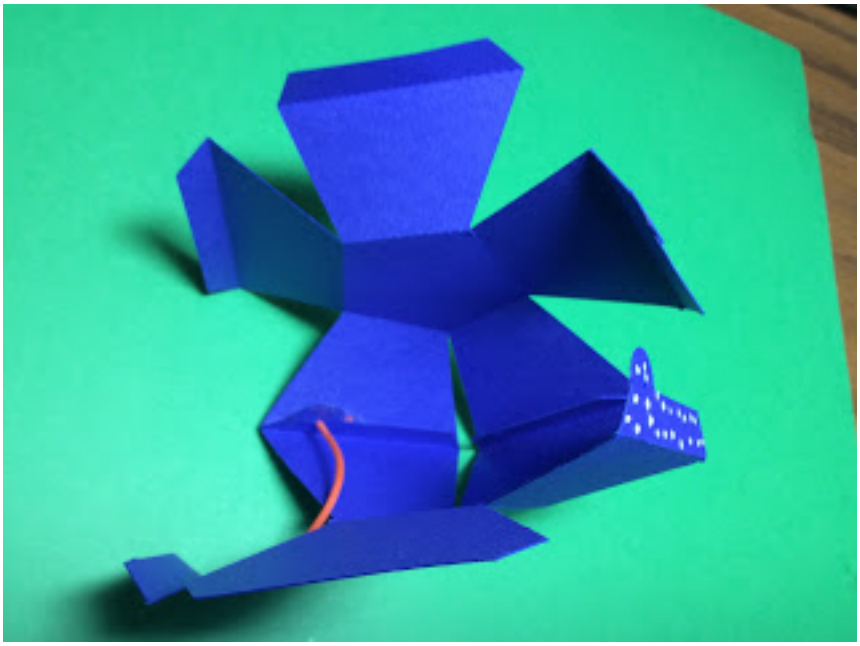
Apply a Glue Dot to the tail of the rubber band.


Cover the Glue Dot and the tail of the rubber band with a piece of Scotch tape.

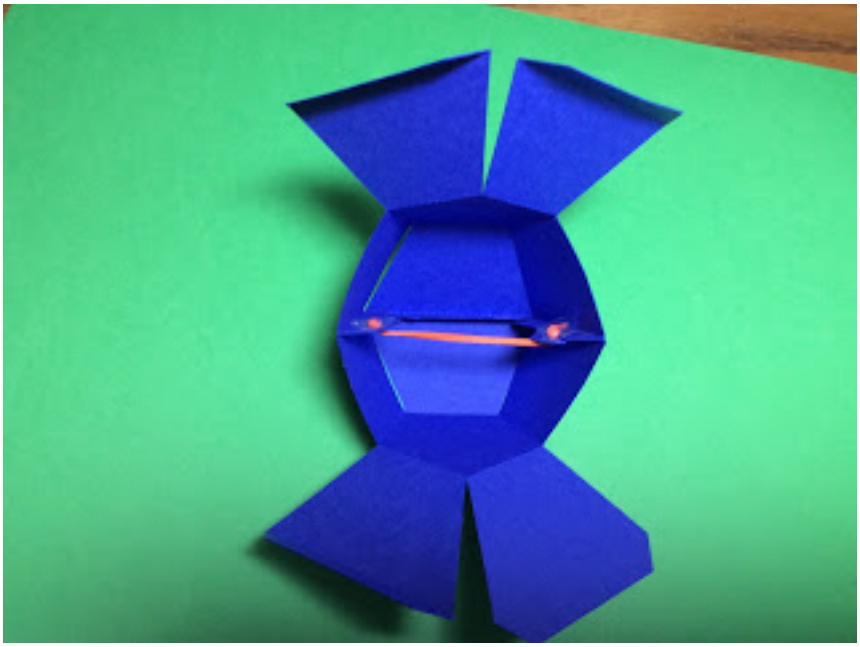


Apply glue to the next tab.

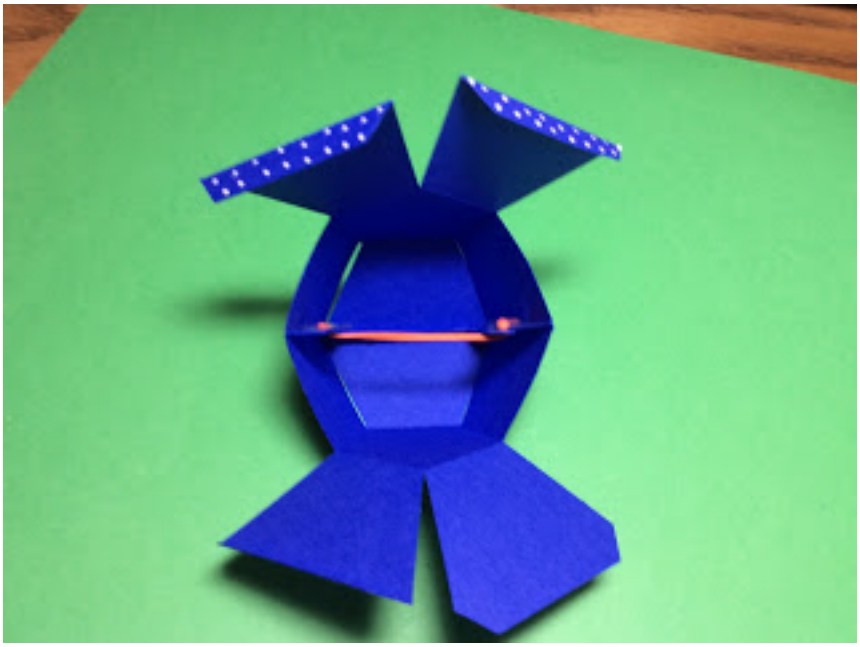
(You want to glue half of the model and then attach the rubber band. The order of gluing for the pentagon should be circle tab, regular tab and then circle tab and NOT circle tab, regular tab, regular tab and circle tab. It will make attaching the rubber band difficult if this order is used).



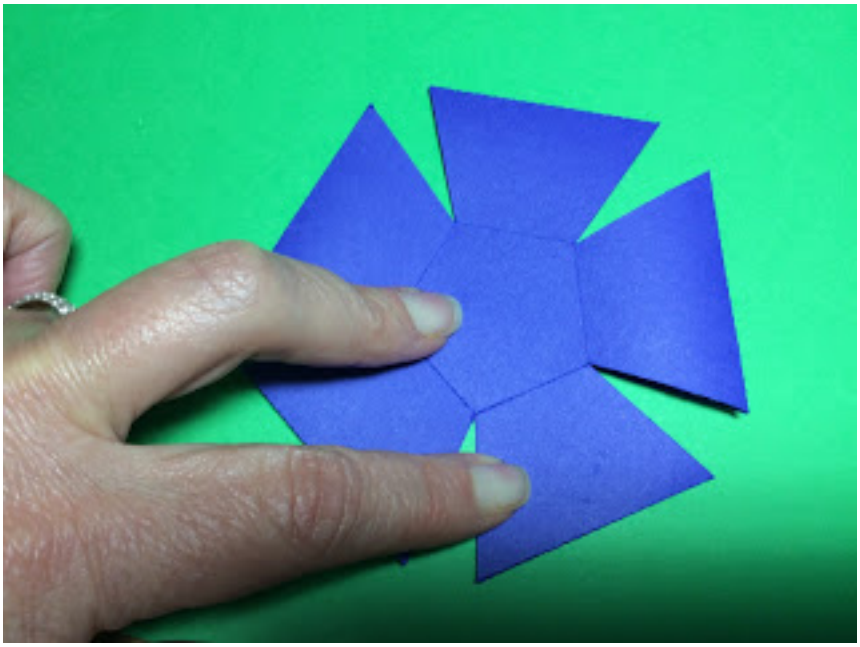
Apply glue to the circle tab and adhere the tabs together.



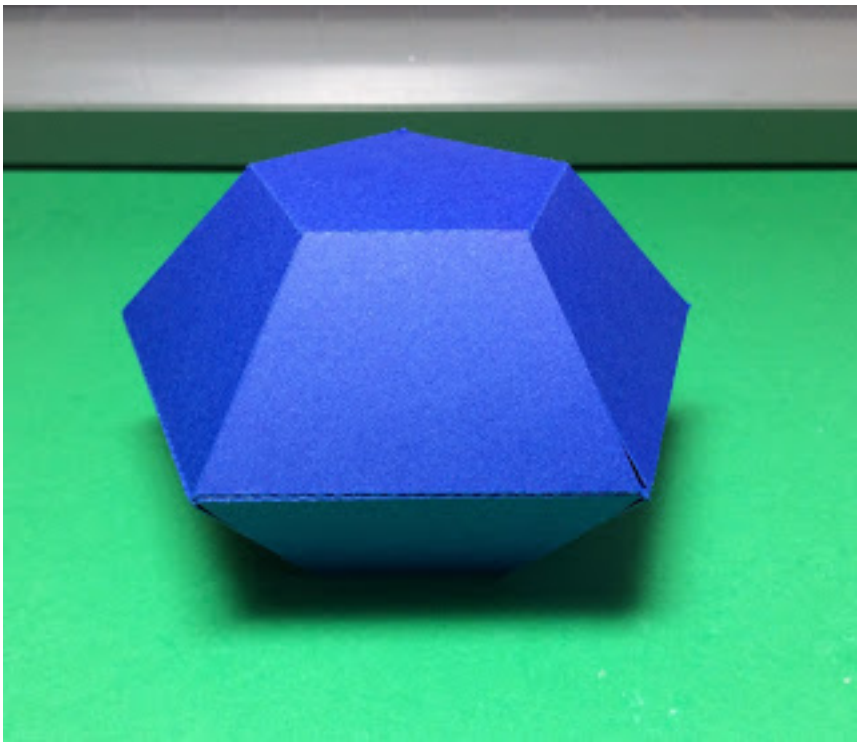
Slide the rubber band onto the slit. Add a Glue Dot and Scotch tape to anchor the rubber band tail.



Apply glue to the remaining two tabs.



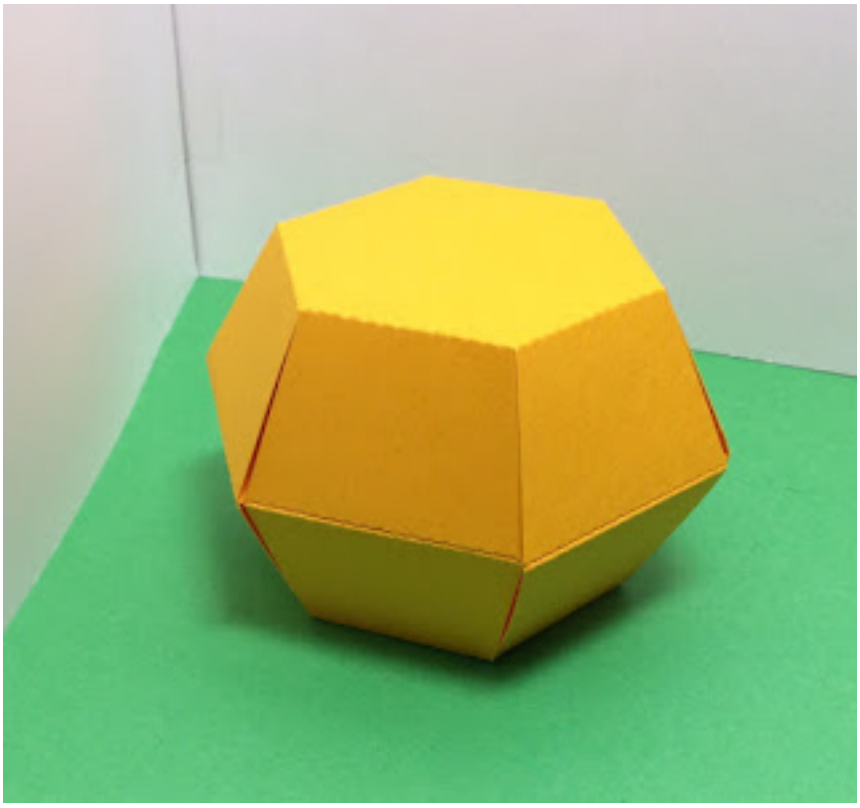
Compress the figure and adhere the glued tabs



Completed Pentagonal Bifrustum

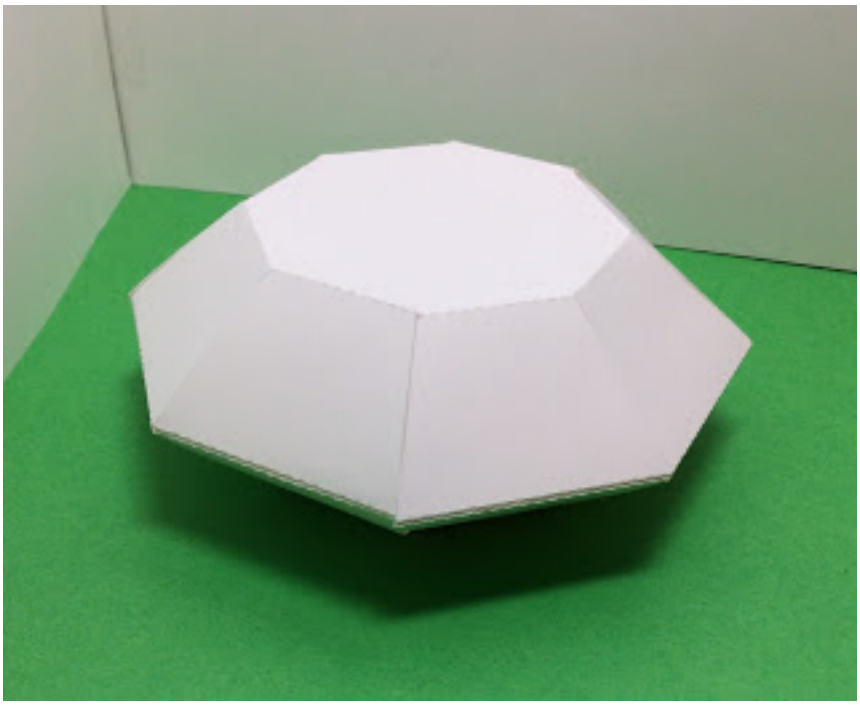
4. Hexagonal Bifrustum	
Faces	12 trapezoids, 2 hexagons

Edges	30
Vertices	18



The instructions to make the hexagonal bifrustum are similar to the the pentagonal bifrustum instructions. Use a 1.375 inch rubber band.
Completed Hexagonal Bifrustum

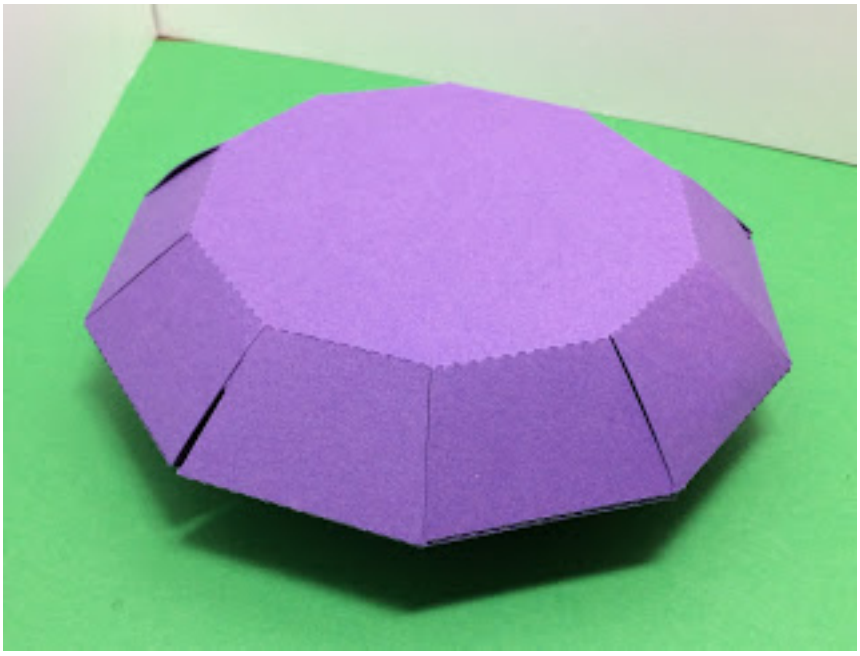
5. Octagonal Bifrustum	
Faces	16 trapezoids, 2 octagons
Edges	40
Vertices	24



The instructions to make the octagonal bifrustum are similar to the the pentagonal bifrustum instructions. Use a 1.56 inch rubber band.

Completed Octagonal Bifrustum

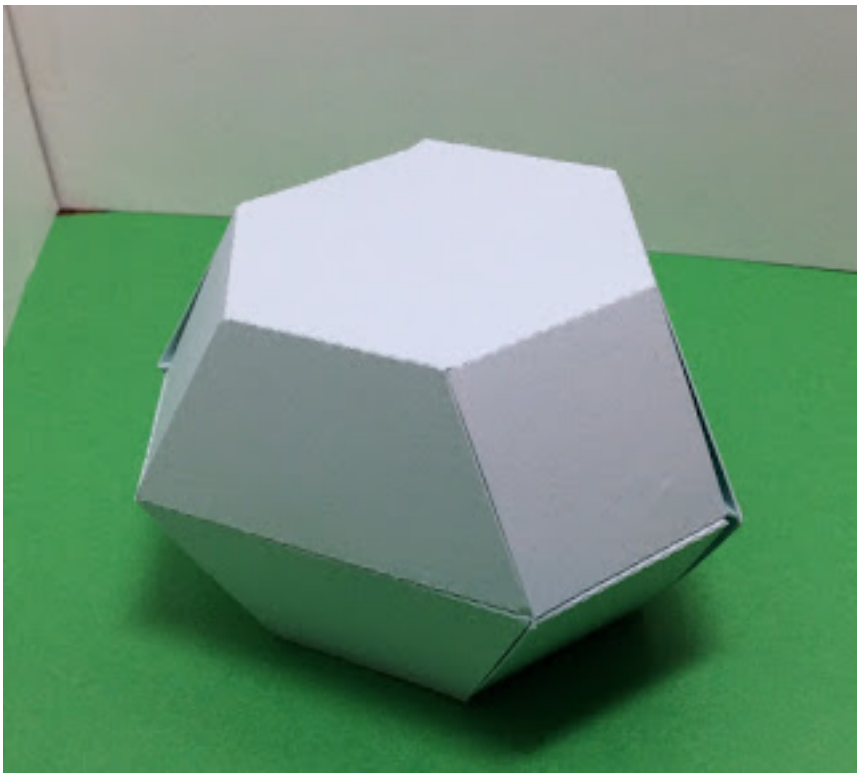
6. Decagon Bifrustum	
Faces	20 trapezoids, 2 decagons
Edges	50
Vertices	30



The instructions to make the decagon bifrustum are similar to the the pentagonal bifrustum instructions. Use a 1.6 inch rubber band.

Completed Decagon Bifrustum

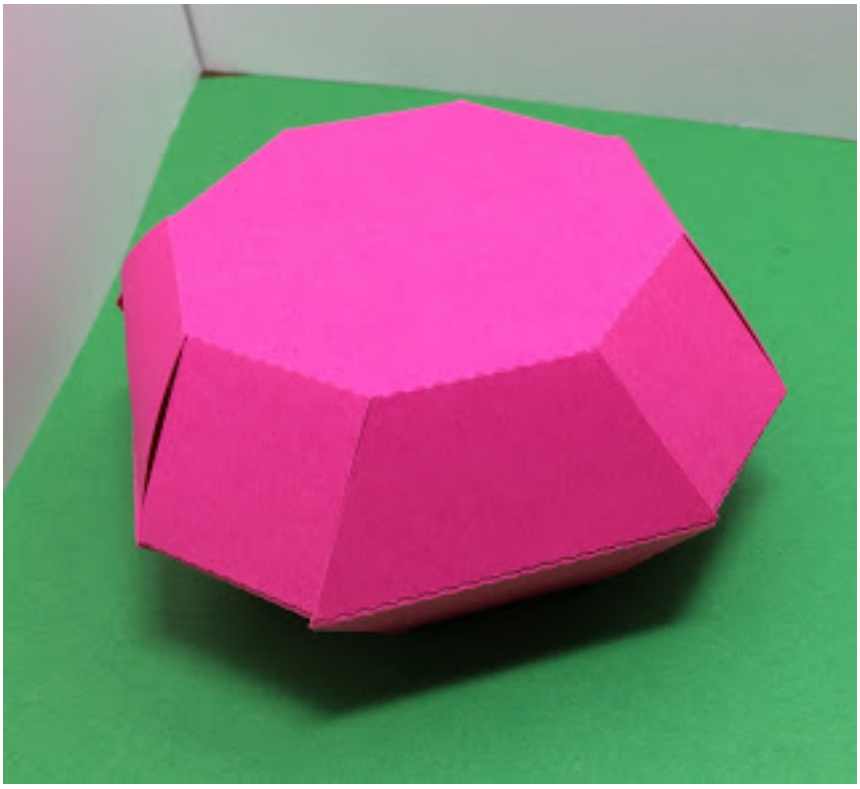
7. Triamond Triangular Bicupola	
Faces	6 trapezoids, 6 squares, 2 hexagons
Edges	30
Vertices	18



The instructions to make the triamond triangular bicupola are similar to the the pentagonal bifrustum instructions. Use a 1.37 inch rubber band.

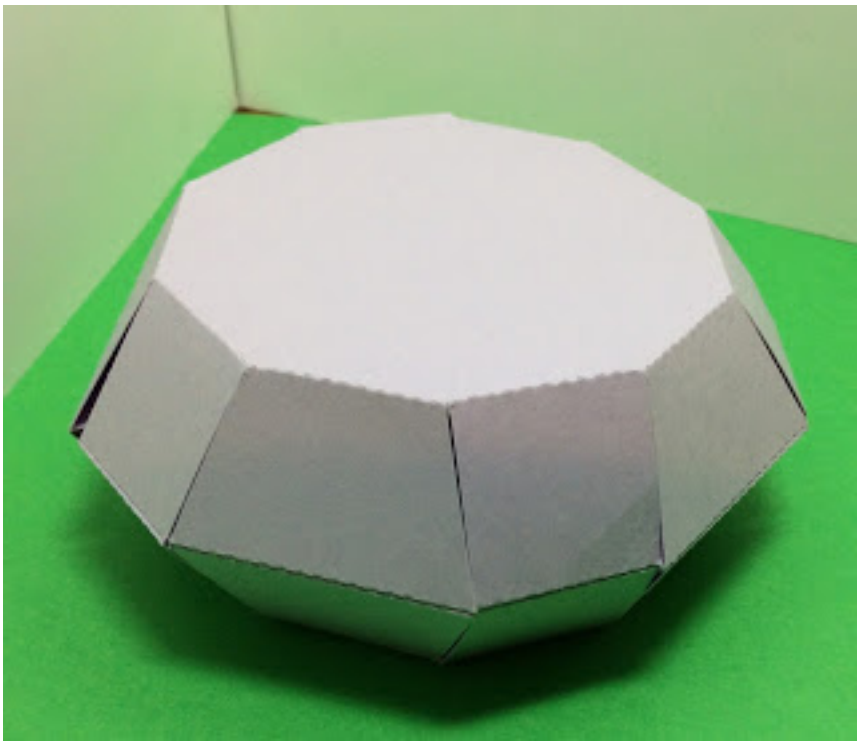
Completed Triamond Triangular Bicupola

8. Triamond Square Bicupola	
Faces	8 trapezoids, 8 squares, 2 octagons
Edges	40
Vertices	24



The instructions to make the triamond square bicupola are similar to the the pentagonal bifrustum instructions. Use a 1.4 inch rubber band.
Completed Triamond Square Bicupola

9. Triamond Pentagonal Bicupola	
Faces	10 trapezoids, 10 squares, 2 decagons
Edges	50
Vertices	30



The instructions to make the triamond pentagonal bicupola are similar to the the pentagonal bifrustum instructions. Use a 1.6 inch rubber band.

Completed Triamond Pentagonal Bicupola