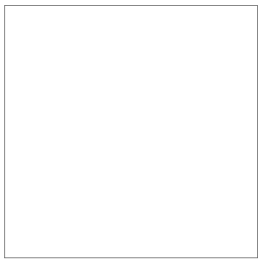
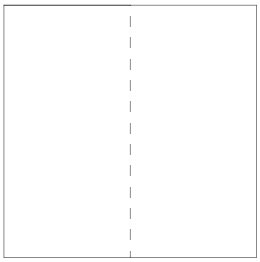
- Activity Name: Origami Polyhedra
- Objectives: As a result of this lesson, the student will be able to assemble and analyze patterns, the augmented tetrahenron (cube), the augmented octahedron, and the augmented icosahedron.
- EALR/Standards:
  - Benchmark 3 – 10 Grade
    - →1.3.1 Properties and relationships – use geometric properties and relationships to contrast, describe, and classify 2-D and 3-D dimensional geometric figures.
    - →1.3.3 Properties and relationships – understand and use properties of symmetry and congruence.
    - →1.3.4 Properties and relationships – perform complex geometric constructions using tools and technologies, such as paper folding…
    - →1.3.6 Locations and transformations – understand and apply multiple geometric transformations using combinations of translations, reflections, and/or rotations.
    - →1.3.7 Relationships and transformations – use a variety of tools and technologies in geometric constructions.
    - →2.1.1 Search systematically for patterns in complex situations
    - →3.1.1 Interpret and integrate information from multiple sources.
    - →4.1 Gather information
    - →4.2 Organize and interpret information
    - →4.3 Represent and share information
- Materials: Five sheets of six colors of origami paper per student
- Teacher Notes:
  - Prerequisites for the learner: None
  - Teacher hints for the activity:
    - Use 12 inch paper as a model. I use 12 by 18 inch fadeless art paper and cut it down to 12 by 12 inch.
    - You can purchase Origami paper in a variety pack from sources like Key Curriculum Press. But I like to use the same 6 so that the students and the instructor will all be talking about and looking at the same colors when we build and discuss the different solids. I suggest the primary colors – red, blue, and yellow – for the cube and the primary & secondary color (red, blue, yellow, orange, green, and purple for the rest.
    - Crisp folds are critical. Sometimes a warm iron will crisp up a unit that has been a challenge.
    - Be sure to note (discuss with your class) the geometric properties, shapes, etc that arise as you fold the unit.
  - Wrap-up questions: See question sheet.
  - Assessment suggestions: Building the shapes is the assessment.
- The Activity: See Instruction sheet.
- Extension: See Extended question sheet.
- References:
  - Unfolding Mathematics with Unit Origami by Betsy Franco, Key Curriculum Press

Instructions for the Unit Origami Fold

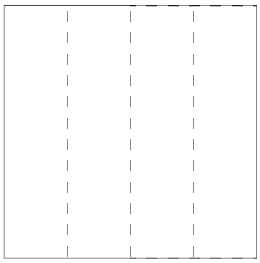
Student Page



1. White Side Up.

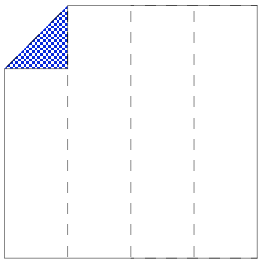


2. Fold left side to the right side.

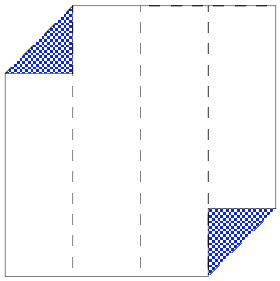


3. Fold left side to the middle.

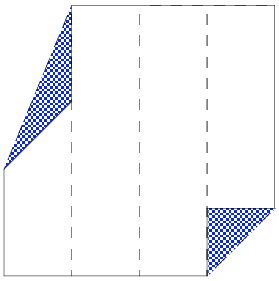
Rotated 180˚ & Repeat.



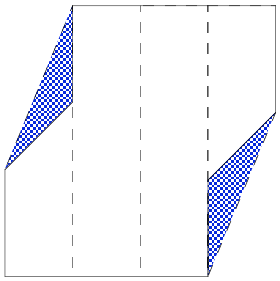
4. Fold the upper left hand corner down so that the top edge lines up with the left-most fold line. *



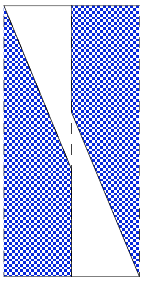
5. Rotate 180˚ and repeat the last step.



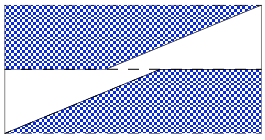
6. Fold the crease down to the first fold. (Creases need to be crisp and straight.)



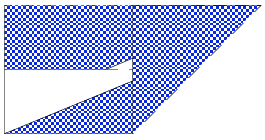
7. Rotate 180˚ and repeat the last step.



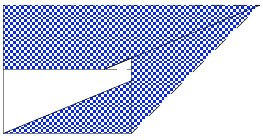
8. Fold the left and the right sides into the centerfold,

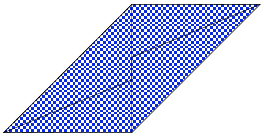


9. Rotate 90˚

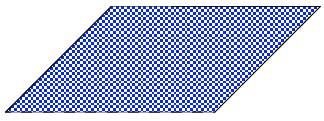


10-11. Fold the right edge up to the top and then tuck under the flap.

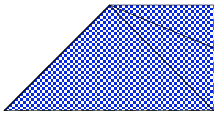




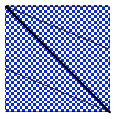
12. Rotate 180˚ and repeat the last two steps



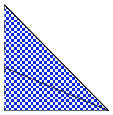
13. Turn over and rotate 90˚.



14. Fold the upper right (acute) angle across to the upper left (obtuse) angle.



15. Rotate 180˚ and repeat.



16. For the Augmented Octahedron and the Augmented Icosahedron, fold the upper right hand corner back down to the bottom left hand corner.

*It makes no difference whether you start with the upper left or the right hand corner. But once you start with one, all the remaining units must be the same.

Instructions for the Unit Origami Fold

Teacher Page

BUILDING THE AUGMENTED POLYHEDRA:

1 There are only three rules for assembling any of the augmented polyhedra

   a. "gozzinto" – whatever color goes into one side of a unit, goes into the other side.

   b. "flaps up" – never cover-up a flap.
   c. 3 colors to a corner – it takes three different color pieces to create a corner (pyramid) as opposed to the number of units around a point.

   Note: It takes three colors around a point for the tetrahedrons, four colors around a point for the octahedron, and five colors around a point for the icosahedron.

2. The tetrahedron takes 2 pieces of 3 colors with three colors around a point.
3. The Octahedron takes 3 pieces of 4 colors with four colors around a point.
4. The Icosahedron takes 5 pieces of 6 colors with five colors around a point.

QUESTIONS:

A WHILE FOLDING THE UNITS:

1 What shape is this? (square)

2 Is this shape similar to the original square? (No.) How does the area of this quadrilateral compare to the original quadrilateral? (The area is in a ratio of 1 to 2.)

3 How do these quadrilateral compare with the original? (The area is in a ratio of 1 to 4.)

4 What is the name of this polygon? (Pentagon.)

5 And this one? (Hexagon)

7 What is the relationship between the pairs of opposite sides? (Parallel and congruent)

10-11 What is the name of this polygon? (Trapezoid)

12-13 What do you call this polygon? (Parallelogram)

14 And this one? (Trapezoid)

15 And this one? (Square) How does it relate to the original square?

Instructions for the Unit Origami Fold Teacher Page

B CUBE (AUGMENTED TETRAHEDRON)

1. Let's look at our augmented tetrahedron (CUBE). Arrange your cube so that the flaps go into the surface facing you from the left and the right (horizontally). If you rotate your cube 90˚ to the left or the right, or up or down? What happens to the color arrangement? To the orientation? Do they change? Do the stay the same?
2. Can you rotate your cube in such a way to keep the orientation and the color pattern?
3. Rotate your cube 180˚. What do you notice? (Ans: You get the same looking face with the same colors and same orientation.) Did everyone rotate the same way? (Probably not.) How did you rotate your cube? (Horizontally – around to the left or the right, vertically – up or down, and around the surface facing you.) Let's all try it that way? Does it work? Do the colors line up the same way? Is the orientation the same? Is there another way to rotate it to keep the color pattern and the orientation the same? (Try to get the class to come up with all three rotations. The rotation of the face on itself will be the toughest one.)
4. How many rotations would it take to get back home?
5. Can you rotate in multiple steps to get keep the orientation and coloring? (90˚ + 90˚)
6. How many such rotations would it take to get home?
7. So far we have been holding the centers of the opposite faces fixed and rotating the cubes. What if we could hold the center of the opposite edges fixed and rotated the cube? What would happen to the color and the orientation?
8. How many rotations would it take to get back home?
9. What if we held the opposite vertices fixed and rotated the cube? What would happen to the color and orientation of the cube?
10. How many rotations would it take to get back home?
11. What happens if you could look through the cube? What would you see?
12. How about if we just use newspaper to make the cube? What kinds of rotations would keep the orientation and color?

C EXTENDED QUESTION (FOR THE AUGMENTED OCTAHEDRON AND AUGMENTED ICOSAHEDRON.)

1. How many pyramids are there in the Octahedron and the Icosahedron?
2. Look at one points. What are the colors around that point? Can you find another point with the same colors around it? In the same order? With the same orientation?
3. How many different combinations of the four colors can there be around any point on the Octahedron? Are all of them on the Octahedron?
4. How about the Icosahderon? We have five colors here?