PFS 28-10 2/11/15 _____

The Stomachion!

The stomachion is often called "the oldest puzzle in the world." It was popular for hundreds of years, and is described by writers as early as 2,200 years ago. The stomachion consists of a square cut up into fourteen pieces. People played with it in two ways. One game was to form figures with the fourteen pieces—for example, a house, or a tree, or a horse. The other game was to put the fourteen pieces together into a square.

The great ancient mathematician Archimedes wrote a treatise about the stomachion, but for many years that treatise was lost except for a brief part preserved in an Arabic manuscript. Then in 1906 a palimpsest was discovered. It was a prayer book made in the 13th century. The creator of the prayer book cut up old books and erased the writing on the pages to make his new book. Among the old books he used were two by Archimedes that were thought to be lost, his *Method* and *The Stomachion*. Although the prayer book has been badly damaged over the years, scientists have used techniques such as x-rays and ultraviolet light to read much of the hidden writing.

We still don't have the whole *Stomachion* by Archimedes, but scholars believe his goal was to discuss the number of different ways the fourteen pieces could form a square. Modern mathematicians have calculated that number to be 536, not counting rotations and reflections. (But remember: finding even one way to put the fourteen pieces into a square can be very very difficult!)

1) Color a drawing of the stomachion.

2) Copy the drawing of the stomachion onto graph paper. Work carefully using a ruler. Then color your copy if you wish.

For the following questions look at the drawing of the stomachion that has each piece labeled with a letter. (Three pairs are labeled A1 and A2, B1 and B2, and C1 and C2. This is because modern mathematicians have discovered that those three pieces always move as a unit in each solution of the square. They could really be glued together, making a simpler puzzle with 11 pieces.) Use the letter names to answer the following questions:

3) Which pieces are triangles? Are there any right triangles?

4) Which pieces are quadrilaterals? Are there any rectangles?

5) Which piece or pieces are pentagons? Are there any pieces with more than five sides?

6) Which piece or pieces have the greatest area? The least area? Are there pairs of pieces that have the same area?

7) Use Pick's Theorem to find the area of some (or all) of the pieces. Pick's theorem is what we worked on last week with Street Corner Polygons. It was first described by Georg Alexander Pick in 1899. It tells us that we can get the area of a street corner polygon by adding up the number of interior points and half the number of border points, and then subtracting one. $A = i + b/2 - 1$. Can you use Pick's theorem to find the areas of the irregularly shaped pieces E, F1, and K? Can you find the area of each piece as a fraction of the whole square?

8) Build your own stomachion puzzle! There are many ways to do this, and you might wish to work with a parent. If you cut up the cardstock drawing prepared by RAF, remember to keep a second drawing so you have a mat to place your pieces on and to help you remember at least one solution. You can also use letters or colors to help you remember a first solution. Put your name on the back of each piece!

9) Once you have pieces to work with, what shapes can you make? Children in ancient times liked to make shapes such as elephants and boats. Can you make a drawing of your creation or photograph it?

10) Once you have pieces to work with, can you learn to put them back together in a square? How many different ways can you find to put them back in a square? Keep a record of any new solutions you discover! Did you find a method for discovering new solutions?

The following questions are for our oldest students:

11) Make a drawing of the stomachion on a coordinate plane as a 12 x 12 square with the lower left corner at (0, 0). What are the coordinates of each interior intersection point?

12) In the same drawing on a coordinate plane, what is the slope of each line in the stomachion? (Make sure your lines are labeled! Suggestion: use letters beginning with L to label vertices since we've used the letters up to K to label the pieces.)

13) What is the length of the longest side of the quadrilateral that has a right angle? Can you find this length two ways, using the distance formula and the Pythagorean Theorem? By the way, does this quadrilateral have *two* right angles? Use your knowledge of slope to answer that question.

14 little pieces and lots of work and fun! If you do research, remember to write it up in your own words and to cite your sources. Richard has prepared a page of links for further learning about the stomachion, and that page will be up on the PFS website.