Faculty of Mathematics and Information Science
WARSAW UNIVERSITY OF TECHNOLOGY

MiNI BLUEBIRD MATH CIRCLE Issue 2: Hogan House Axioms

Share your problems, solutions, models, stories, and art: https://akademia.mini.pw.edu.pl/pl/ukraina

Build communities, not just houses.

—Roberto Nutlouis, Navajo youth leader, builder, and agriculturist; his teams built and photographed all hogan houses in this newsletter (used with permission)

NEWSFLASH Join LIVE the MiNI Bluebird Math Circle to work on these activities together with friends and family. The math circle is in English and Ukrainian with live translation.
Monday August 1st, 18:30-20:00 Warsaw, Poland time, online.

Sign up at https://akademia.mini.pw.edu.pl/pl/ukraina

MATH JOKE

My son said, "I got a D in my math."

I said, "That's really bad!"

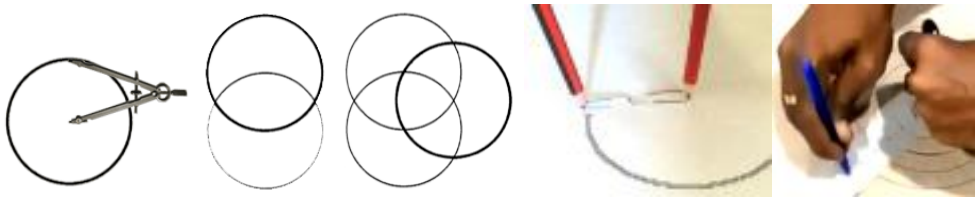
My wife said, "You need to stop doing his homework!"

Submitted by J.C. Elliott

Warm up: Japanese and Greek geometries

Geometries (there are many!) are math abstractions. They come from practices in people's art and trades. Let's start from two such "origin stories." Make a paper flier and draw these circle designs to get a quick taste of these geometries.

Paper fliers: a taste of origami constructions from Japan.



Drawing with a compass: a taste of architecture constructions from Greece. If you don't have a compass, use a paperclip and two pencils, or a strip of paper with holes.

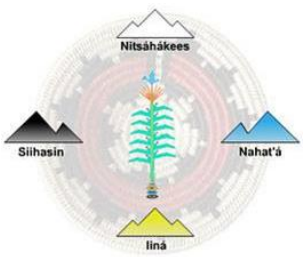
The geometry that grew from origami is called Huzita-Hatori Axioms. The geometry that grew from compass and straightedge constructions is called Euclid's Axioms. In geometries, **axioms** are building steps we hold true and self-evident. An origami axiom: we can make a fold that places any line onto any other line (like matching our flier's wings). A Euclid's axiom: we can draw a straight line from any point to any point.

Family Circle: Building the Hogan house and the Navajo geometry

The rope and the circle—The hogan is a traditional home for the Diné (Navajo) people. We will model some steps for building different hogans. First hogans were round. Two builders laid out a circle using some rope. Then they constructed walls from vertical cedar logs.

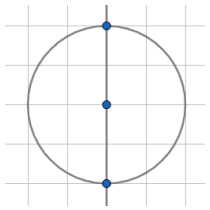
If you are doing this outside, use a rope and a sharp stick to mark a big circle on the ground. If you are doing this at home, use a strip of paper with two holes for pencils instead of a rope.

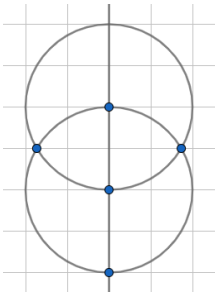
The directions and the door—Navajo builders use the cardinal directions: East-West and South-North. If you are doing this outside, you can model their methods using modern tools such as the GPS in a smartphone. If you are doing this on paper, pretend the top of your paper is East. Use a second sheet of paper as a ruler (lined it up, edge to edge), or use the lines on graph paper. Draw an East-West line through your round hogan, and mark an opening for the door. The door always opens to the East!



Six-sided hogan—Some hogan homes have six sides. There are several ways you can lay out a perfect hexagon using the Navajo method.

1. Start with a circle.
2. Stretch your rope (if outside) or your paper strip and use it to draw a straight East-West line through the center of your circle.
3. Using the same length of the rope, draw two more identical circles, centered where your line crosses your first circle.
4. The intersection points lay out a perfect hexagon! Now you are ready to build the walls of your hexagonal hogan house.





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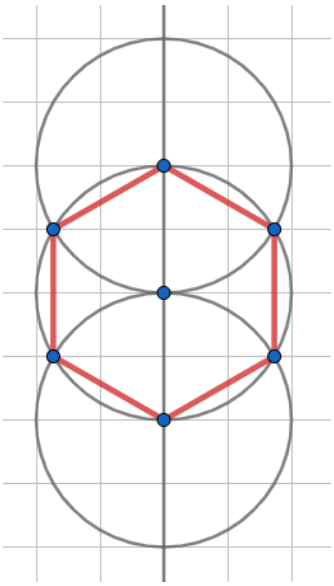


Eight-sided hogan—Most hogan houses have eight sides. The math department building at Diné College has an octagonal foundation, as well as many other campus buildings:

Experiment with your rope and your cardinal directions to lay out a perfect octagon.

Building tips:

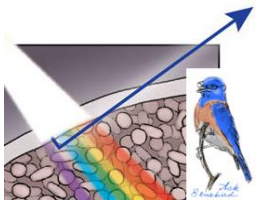
- Your rope (or your paper strip) is flexible. You can fold it in two to find the middle of any line. That even works for curved lines, such as arcs!
- If you find both East-West and South-North lines, you can build a straight (90 degree) angle.

More constructions—Experiment with your rope (or paper strip) and the cardinal directions to try some other practical or famous geometric constructions. Here are a few ideas to try:

- Draw parallel lines.
- Make a regular triangle, square, pentagon, and other regular polygons.
- Help out the ancient Greeks with problems famously unsolvable by Euclid geometry: trisecting an angle or squaring the circle.
- If you have some experience with axioms, draft a set of **hogan house axioms**.

Ask Bluebird

QUESTION—*Why are bluebirds blue?* - from Mark Saul



BLUEBIRD SAYS—In bluebirds, the color doesn't appear from pigmentation, as it does in most other birds (or in us). For bluebirds, it's all about reflection! When white light strikes a bluebird's feather, the precise patterns in its cell get to work. Reflections cause red and yellow wavelengths to cancel each other out. Meanwhile, blue wavelengths of light amplify one another, then reflect back to our eyes. This is called *structural color*.

NAVAJO STORY—There was a time when animals were choosing their colors. They were also deciding if we should have all night, or all day, when the world was being created. There were games, but nobody was winning, and different animals were cheating. So they kept it 50-50. Back then, all beings looked the same. So after the last game, they were given paint. The birds and animals could pick the colors they wanted. And the bluebirds picked blue!

FUN FACT OF THE FORTNIGHT	Many cultures around the world build structures without rulers, compasses, or protractors. How do they measure lengths and angles? They use their hands, arms, feet—their body parts. They may also use materials found in nature, such as sticks and rocks.