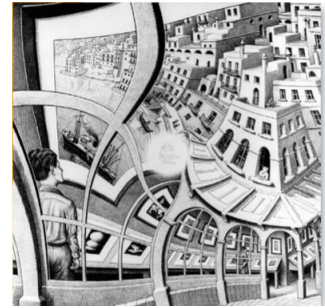


Geometric Art Portfolio Project

In this project, you will

- See examples of geometry in nature
- Study geometric art forms of cultures around the world
- Study the symmetry in flowers, crystals, and animals
- See geometry as a way of thinking and of looking at the world

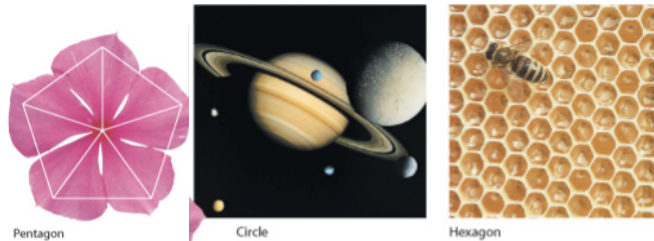


M.C. Escher

The goal of this project is for you to see that geometry is a way of thinking about and seeing the world and for you to become aware of geometry in nature, and discover that geometry is alive in cultures and art forms around the world. There is a good deal of reading about geometric art, but what you learn through the readings and pictorial examples will help you to create your own portfolio of geometric art.

Part 1: Geometry in Nature and in Art

Reading: Nature displays a seemingly infinite variety of geometric shapes, from tiny atoms to great galaxies. Crystals, honeycombs, snowflakes, spiral shells, spiderwebs, and seed arrangements on sunflowers and pinecones are just a few of nature's geometric masterpieces.



Pentagon

Circle

Hexagon

Geometry includes the study of the properties of shapes such as circles, hexagons, and pentagons. Outlines of the sun, the moon, and the planets appear as circles. Snowflakes, honeycombs, and many crystals are hexagonal (6-sided). Many living things, such as flowers and starfish, are pentagonal (5-sided).

People observe geometric patterns in nature and use them in a variety of art forms. Basket weavers, woodworkers, and other artisans often use geometric designs to make their works more interesting and beautiful. You will learn some of their techniques in this project.



This Islamic design from Egypt uses 4-sided and 6-sided shapes, as well as 5-pointed and 12-pointed stars.

In the Celtic knot design above, the curves seem to weave together.

Artists rely on geometry to show perspective and proportion, and to produce certain optical effects. Using their understanding of lines, artists can give depth to their drawings. Or they can use lines and curves to create designs that seem to pop out of the page.

Hungarian artist Victor Vasarely (1908–1997) had a strong interest in geometry, which was reflected in his work. In this series, he used curved lines to produce the illusion of three spheres.

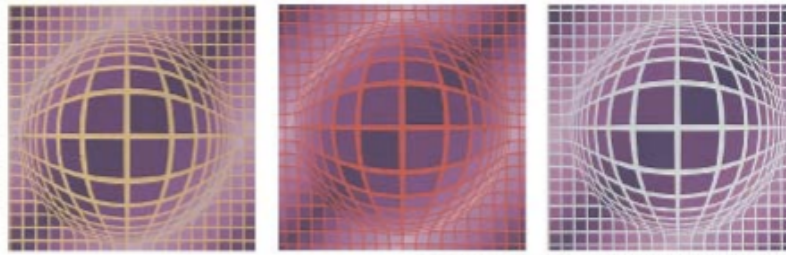
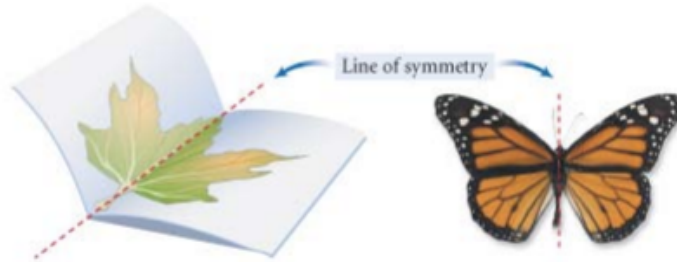


Figure 1.1.11 (1991), Victor Vasarely, courtesy of the artist.

Symmetry is a geometric characteristic of both nature and art. You may already know the two basic types of symmetry, reflectional symmetry and rotational symmetry. A design has **reflectional symmetry** if you can fold it along a **line of symmetry** so that all the points on one side of the line exactly coincide with (or match) all the points on the other sides of the line.

This leaf and butterfly both have one line of reflectional symmetry.



You can place a mirror on the line of symmetry so that half the figure and its mirror image recreate the original figure. So, reflectional symmetry is also called *line symmetry* or *mirror symmetry*. Biologists say an organism with just one line of symmetry, like the human body or a butterfly, has *bilateral symmetry*. An object with reflectional symmetric looks balanced.

A design has **rotational symmetry** if it looks the same after you turn it around a point by less than a full circle. The number of times that the design looks the same as you turn it through a complete 360° circle determines the type of rotational symmetry. The Apache basket has 3-fold rotational symmetry because it looks the same after you rotate it 120° (a third of the circle), 240° (two-thirds of a circle), and 360° (one full circle).



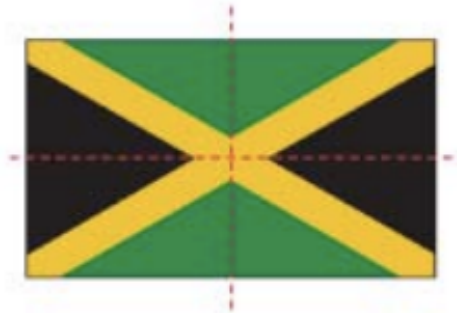
This Apache basket has 3-fold rotational symmetry.

A starfish has 5-fold symmetry. It looks the same after you rotate it 72° , 144° , 216° , 288° , and 360° .

The square fabric has 4-fold rotational symmetry and a starfish has 5-fold rotational symmetry. What type of rotational symmetry does a circular plate have?



Countries through the world use symmetry in their national flags. Notice that the Jamaican flag has rotational symmetry in addition to two lines of reflectional symmetry. You can rotate the flag 180° without changing its appearance. The origami boxes, however, have rotational symmetry, but not reflectional symmetry.



The Jamaican flag has two lines of reflectional symmetry.



If you ignore colors, the Japanese origami box on the left has 3-fold rotational symmetry. What type of symmetry does the other box have?

Task: Use the nature and art examples from the reading to inspire your creations of:

- 1 art piece that has only reflectional symmetry
- 1 art piece that has only rotational symmetry
- 1 art piece that has both reflectional and rotational symmetry

Think outside of the box and be creative in your art pieces!

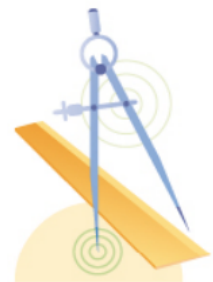
After you have created your art pieces, it is time to play art gallery...

- Give your art piece a cool title (make sure you sign your work like a true artist!)
- Write a description of your art piece ***including why it has reflectional/rotational symmetry and what mathematics did you learn or apply in this piece***. You may also include details on what materials you used, your inspiration, etc. like real art pieces do in museums and such.

Part 2: Line Designs

Reading: The symmetry and patterns in geometric designs make them very appealing. You can make many design patterns using the basic tools of geometry—**compass** and **straightedge**.

You'll use a straightedge to construct straight lines and a compass to construct circles and to mark off equal distances. A straightedge is like a ruler but it has no marks. You can use the edge of a ruler as a straightedge. The straightedge and the compass are the classical construction tools used by the Ancient Greeks, who laid the foundations of the geometry that you have studied.



Japanese design is known for its simple, clean lines.



The complementary line designs on the arched ceiling and tile floor make this building lobby look grandiose.

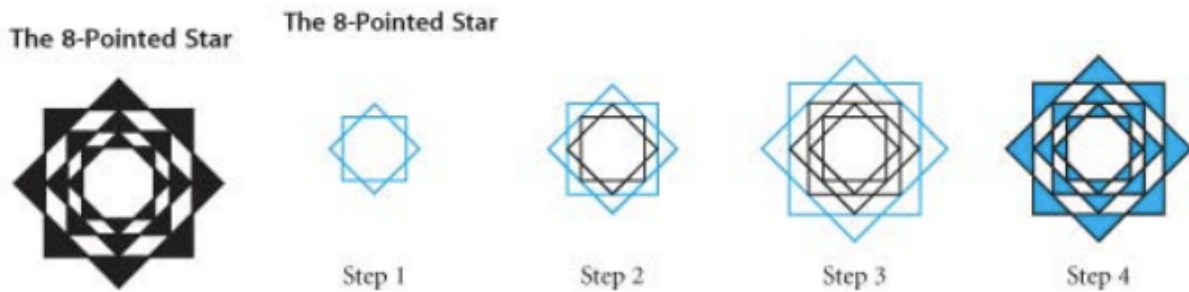
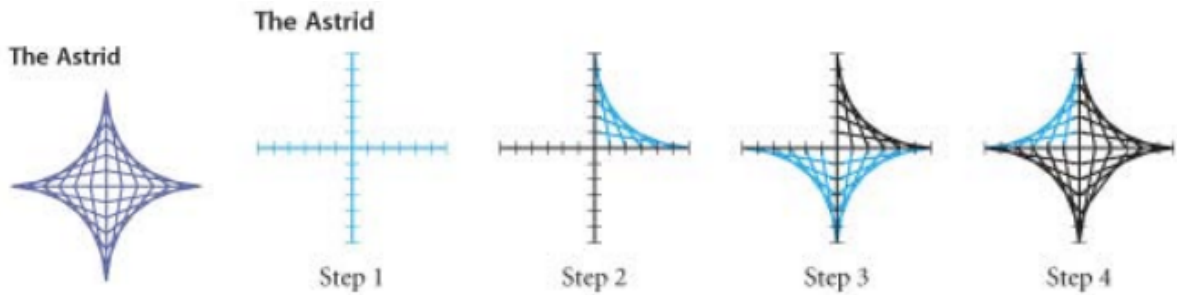


Notice how the patterns of these Guatemalan rugs are a non-uniform and dynamic arrangement of lines.



Some of the lines in this mosaic appear to be tied in knots!

You can create many types of designs using only straight lines. Here are two line designs and the steps for creating each one.



Task: Use the line design examples from the reading to inspire your creation of:

- 1 line design art piece

After you have created your art pieces, it is time to play art gallery...

- Give your art piece a cool title (make sure you sign your work like a true artist!)
- Write a description of your art piece ***including why it is an example of a line design and what mathematics did you learn or apply in this piece.*** You may also include details on what materials you used, your inspiration, etc. like real art pieces do in museums and such.

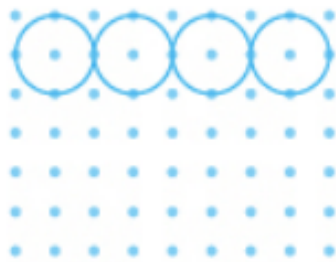
Part 3: Circle Designs

Reading: People have always been fascinated by circles. Circles are used in the design of mosaics, baskets, and ceramics, as well as in the architectural design of buildings.

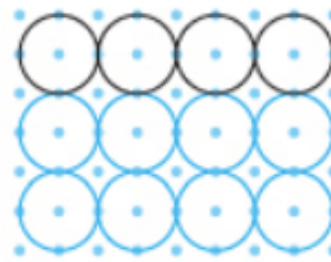


You can make circle designs with a compass as your primary tool. For example, here is a design you can make on a square dot grid.

Begin with a 7-by-9 square dot grid. Construct three rows of four circles.

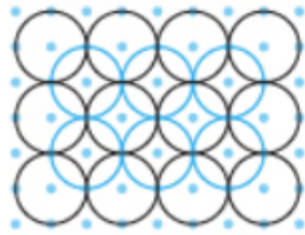


Step 1

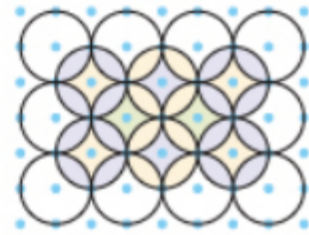


Step 2

Construct two rows of three circles using points between the first set of circles as centers. The result is a set of six circles overlapping the original 12 circles. Decorate your design.



Step 3



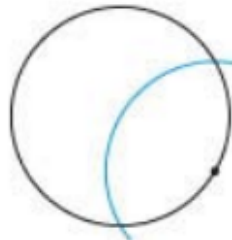
Step 4

Here is another design that you can make using only a compass. Start by constructing a circle, then select any point on it. Without changing your compass setting, swing an arc centered at the selected point. Swing an arc with each of the two new points as centers, and so on.

The Daisy



Step 1



Step 2



Step 3



Step 4

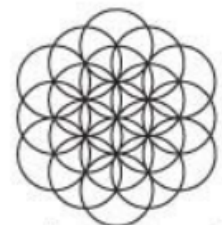


Step 5



Step 6

Notice that the shape you get by connecting the six petal tips of the daisy. This is a **regular hexagon**, a 6-sided figure whose sides are the same length and whose angles are all the same size.



Instead of stopping at the perimeter of the first circle, you can continue to swing full circles. Then you get a "field of daisies," as shown above.

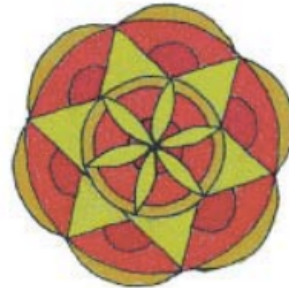
You can do many variations on a daisy design.



12-petal daisy



Field of daisies



Combination line and circle design
(Can you see how it was made?)

Schuyler Smith, geometry student

Task: Use the circle design examples from the reading to inspire your creation of:

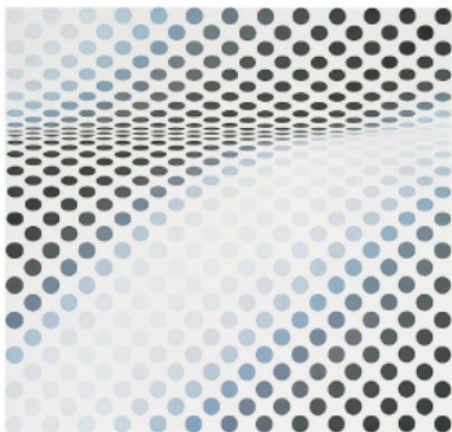
- 1 circle design art piece

After you have created your art pieces, it is time to play art gallery...

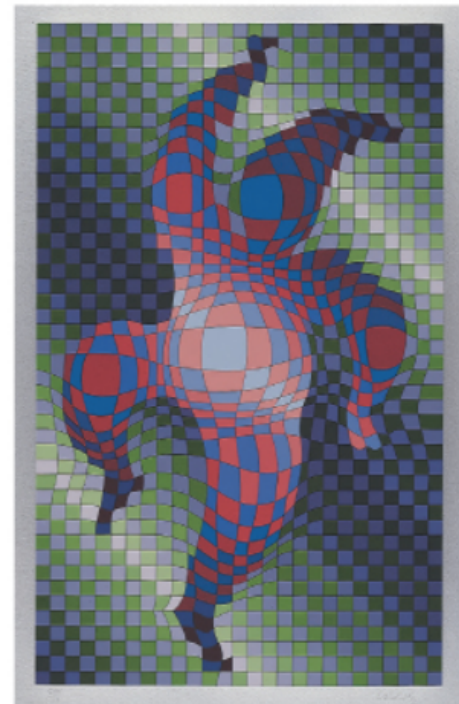
- Give your art piece a cool title (make sure you sign your work like a true artist!)
- Write a description of your art piece ***including why it is an example of a circle design and what mathematics did you learn or apply in this piece.*** You may also include details on what materials you used, your inspiration, etc. like real art pieces do in museums and such.

Part 4: Op Art

Reading: Op art, or optical art, is a form of abstract art that uses lines or geometric patterns to create a special visual effect. The contrasting dark and light regions sometimes appear to be in motion or to represent a change in surface, direction, and dimension. Victor Vasarely was one artist who transformed grids so that spheres seem to bulge from them. Recall the series *Tsiga I, II, III* that appear in Part 1. *Harlequin*, shown at right, is a rare Vasarely work that includes a human form. Still, you can see Vasarely's trademark sphere in the clown's bulging belly.



In *Hesitate*, by contemporary op artist Bridget Riley (b 1931),

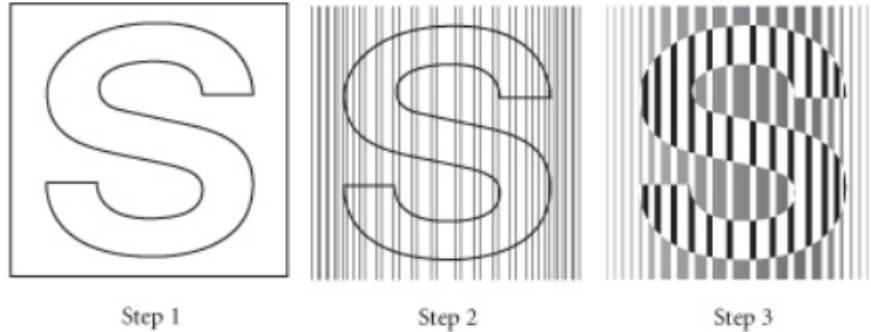


In *Harlequin*, Victor Vasarely used curved lines and shading to create the form of a clown in motion.

Harlequin, Victor Vasarely, courtesy of the artist.

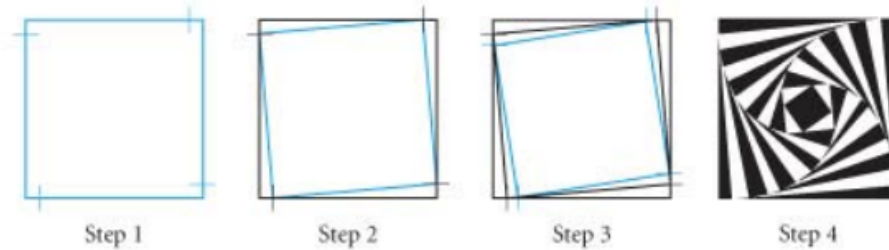
Op art is fun and easy to create. To create one kind of op art design, first make a design in outline. Next, draw horizontal or vertical lines, gradually varying the space between the lines or each pair of lines, as shown below, to create an illusion of hills and valleys. Finally, color in or shape alternating spaces.

The Wavy Letter



To create the next design, first locate a point on each of the four sides of a square. Each point should be the same distance from a corner, as shown. Your compass is a good tool for measuring equal lengths. Connect these four points to create another square within the first. Repeat the process until the squares appear to converge on the center. Be careful that you don't fall in!

The Square Spiral



Here are some other examples of op art.



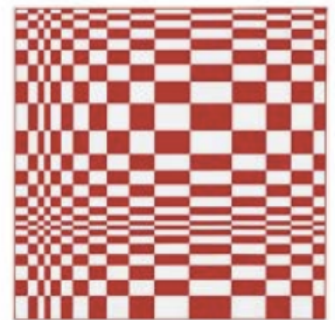
Square tunnel or top of pyramid?



Amish quilt, tumbling block design



Japanese Op Art, Hajime Juchi, Dover Publications



Op art by Carmen Apodaca, geometry student

You can create any of the designs on this page using just a compass and straightedge (and doing some careful coloring). Can you figure out how each of these op art designs was created?

Task: Use the op art design examples from the reading to inspire your creation of:

- 1 op art design art piece

After you have created your art pieces, it is time to play art gallery...

- Give your art piece a cool title (make sure you sign your work like a true artist!)
- Write a description of your art piece ***including why it is an example of an op art design and what mathematics did you learn or apply in this piece.*** You may also include details on what materials you used, your inspiration, etc. like real art pieces do in museums and such.

Part 5: Knot Designs

Reading: Knot designs are geometric designs that appear to weave or to interlace like a knot. Some of the earliest known designs are found in Celtic art from the northern regions of England and Scotland.

In their carved stone designs, the artists imitated the rich geometric patterns of three-dimensional crafts such as weaving and basketry. The *Book of Kells* (8th and 9th centuries) is the most famous source of Celtic knot designs.



Celtic knot design

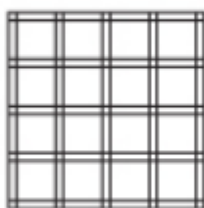


Carved knot pattern from Nigeria

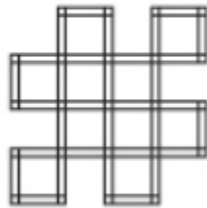
Today a very familiar knot design is the set of interconnected rings (shown at right) used as the logo for the Olympic Games.



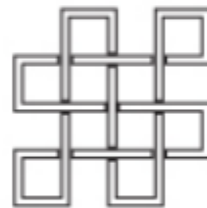
Here are the steps for creating two examples of knot designs. Look them over before you try.



Step 1



Step 2

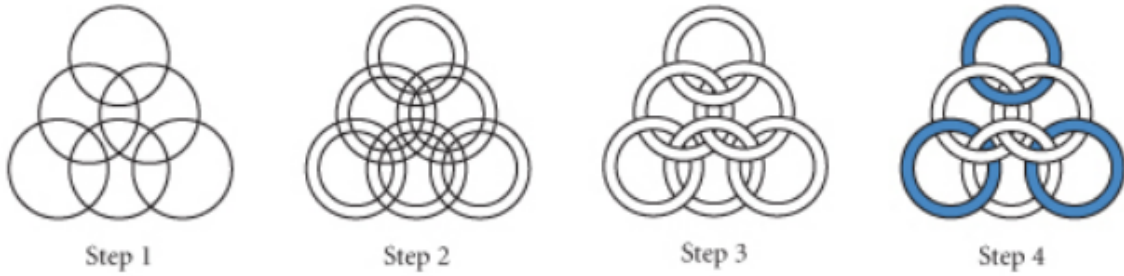


Step 3



Step 4

You can use a similar approach to create knot designs with rings.



Here are some more examples of knot designs.



Knot design by Scott Shanks, geometry student



Tiger Tail, Diane Cassell, parent of geometry student



Medieval Russian knot design



Japanese knot design

The first woodcut made by M. C. Escher is a knot design called *Snakes*. The rings and the snakes interlace, and the design has 3-fold rotational symmetry.
Snakes, M. C. Escher, 1969/ ©2002 Cordon Art B. V.-Baarn-Holland. All rights reserved.



Task: Use the knot design examples from the reading to inspire your creation of:

- 1 knot design art piece

After you have created your art pieces, it is time to play art gallery...

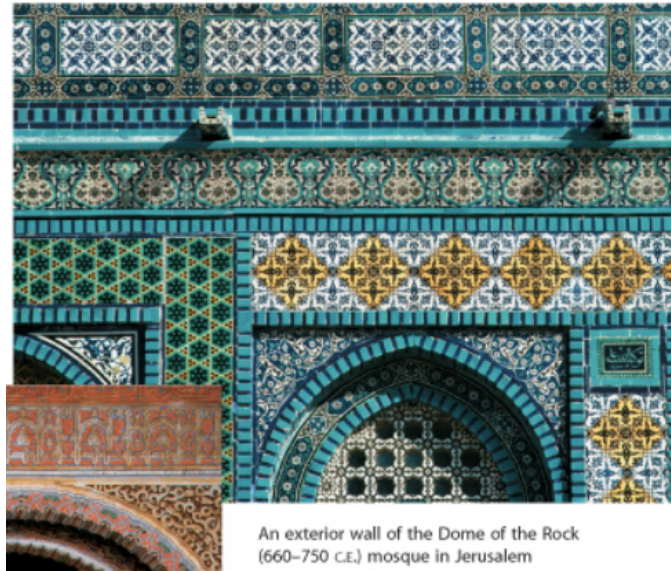
- Give your art piece a cool title (make sure you sign your work like a true artist!)
- Write a description of your art piece ***including why it is an example of a knot design and what mathematics did you learn or apply in this piece.*** You may also include details on what materials you used, your inspiration, etc. like real art pieces do in museums and such.

Part 6: Islamic Tile Designs

Reading: Islamic art is rich in geometric forms. Early Islamic, or Muslim, artists became familiar with geometry through the works of Euclid, Pythagoras, and other mathematicians of antiquity, and they used geometric patterns extensively in their art and architecture.



Alcove in the Hall of Ambassadors, the Alhambra, in Granada, Spain



An exterior wall of the Dome of the Rock (660–750 C.E.) mosque in Jerusalem

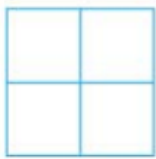
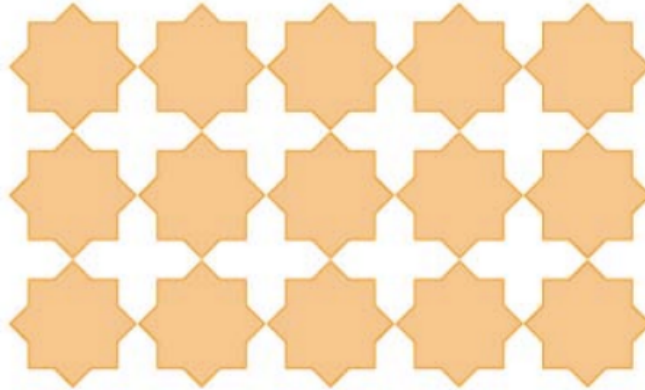
Islam forbids the representation of humans or animals in religious art. So, instead, the artists use intricate geometric patterns.

One striking example of Islamic architecture is the Alhambra, a Moorish palace in Granada, Spain. Built over 600 years ago by Moors and Spaniards, the Alhambra is filled from floor to ceiling with marvelous geometric patterns. The designs you see on this page are but a few of the hundreds of intricate geometric patterns found in the tile work and the inlaid wood ceilings of buildings like the Alhambra and the Dome of the Rock.

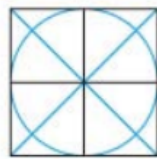
Carpets and hand-tooled bronze plates from the Islamic world also show geometric designs. The patterns often elaborate on basic grids or regular hexagons, equilateral triangles, or squares. These complex Islamic patterns were constructed with no more than a compass and a straightedge. Repeating patterns like these are called **tessellations**.

The two examples below show how to create one tile in a square-based and a hexagon-based design. The hexagon-based pattern is also a knot design.

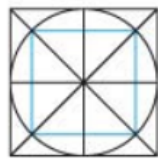
8-Pointed Star



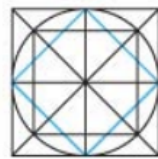
Step 1



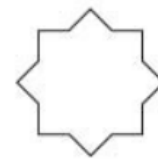
Step 2



Step 3

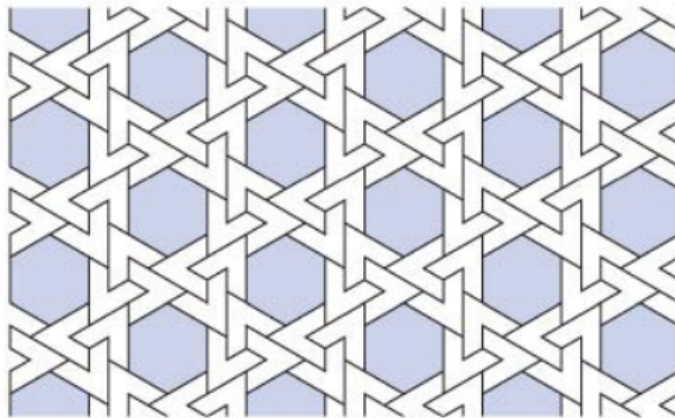


Step 4



Step 5

Hexagon Tile Design



Step 1



Step 2



Step 3



Step 4



Step 5



Task: Use the Islamic tile design examples from the reading to inspire your creation of:

- 1 Islamic tile design art piece

After you have created your art pieces, it is time to play art gallery...

- Give your art piece a cool title (make sure you sign your work like a true artist!)
- Write a description of your art piece ***including why it is an example of an Islamic tile design and what mathematics did you learn or apply in this piece.*** You may also include details on what materials you used, your inspiration, etc. like real art pieces do in museums and such.

Part 7: Portfolio and Gallery Walk

Now, after all the hard work and creativity you have put into your art designs, it is time to display your portfolio of work like an artist showcasing at a real art gallery. You will stage all your pieces around the classroom with your descriptions posted next to your piece. You will act as the artist, an observer, and an evaluator.

As the artist, you will talk about your pieces with fellow gallery guests and provide explanations to any questions they may have. As an observer, you will view your fellow classmates' pieces and ask any questions you may have about their work. As an evaluator, you will provide feedback to your fellow classmates by completing an evaluator card for each piece.

Good luck, have fun, and enjoy yourself!