

**TOPIC:** Geometry, Islamic Art and Culture

**NCTM STANDARDS:** Geometry, Patterns, Measurement

**GOALS:**

Students will develop an understanding of shapes and patterns through Islamic art and culture. They will examine basic geometric concepts of symmetry and area, as well as develop their skills with a compass and straight edge.

**INTRODUCTION:**

Islamic art is centered on geometric designs. It has been used to decorate various facades of artifacts, and is most notable in architecture. A small number of repeated geometric elements combine to create these patterns. Through different colors and shading, artists construct a foreground and a background within the motif. In addition, the repetition makes them seem infinite because the designs are not intended to be contained by the structure that they adorn. One of these patterns, which we will study in depth, is made by five overlapping circles.

**ACTIVITIES:**

- Part 1. Introduction. Students use the internet to research the Islamic religion and the reason for their use of geometry in their art. They take notes on their findings and share them within groups. The main ideas are briefly outlined and summarized as a class.
- Part 2. Symmetry and Area. Students use a compass and straight edge to draw a pattern template. They analyze the shape's area and symmetries, and use this template to determine the number of figures needed to border one edge of a ten meter wall.
- Part 3. Geometric Figures. Using the traditional methods of Islamic art, students create geometric shapes within the circles of the pattern template. Students will also develop their own methods of creating geometric shapes not necessarily found in traditional Islamic art.

**ASSESSMENT:** After studying traditional Islamic art, students create their own geometric pattern, decorating it on construction paper and analyzing its symmetry in an attached paragraph.

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Fukushima, C. & Hens, M. (2004). *Islamic Art and Geometric Design: Activities for Learning*. New York: Metropolitan Museum of Art.

### Part 1. Introduction.

Islamic art and decoration is limited by the religion. Research the history of the geometric patterns in art using the following websites, and others if you choose. Specifically, look for patterns using overlapping circles. What artifacts do they adorn? How are the circles used to distinguish other shapes? How does the coloring and shading change how you view the shapes? You will discuss your findings in groups, and we will summarize them together as a class.

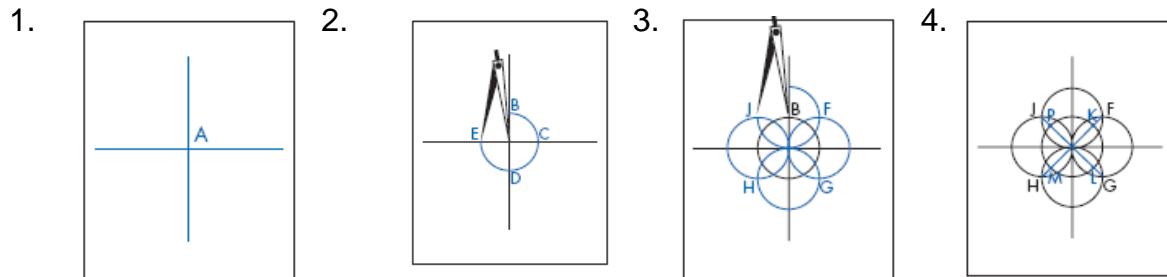
[http://www.salaam.co.uk/themeofthemonth/march02\\_index.php?l=3](http://www.salaam.co.uk/themeofthemonth/march02_index.php?l=3)

[http://www.metmuseum.org/toah/hd/geom/hd\\_geom.htm](http://www.metmuseum.org/toah/hd/geom/hd_geom.htm)

### Part 2. Symmetries and Area.

Using a straight edge and a compass, follow the attached instructions to create five overlapping circles. Then answer the questions below.

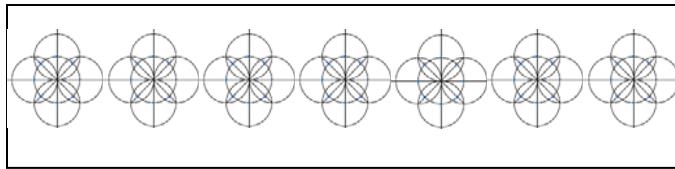
1. Bisect the page by drawing one horizontal and one perpendicular line. Mark the center as A.
2. Place the compass point at point A and draw a circle. Leave room to draw equal sized circles on each side, at the bottom, and at the top. Mark the points that cross the lines B, C, D, and E.
3. Using points B, C, D and E, draw four more circles. Mark the points where the four circles intersect F, G, H, and J.
4. Use a straightedge to draw the lines FH and JG through the center. These lines intersect the original circle at four equally spaced points at K, L, M, and P.
5. The straight lines both divide the circle into eight equal parts and locate eight equally spaced points—B, C, D, E, K, L, M, P—on the circumference of the original circle. This is the result of the five circles having the same radius.



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Images: Fukushimo, C. & Hens, M. (2004). *Islamic Art and Geometric Design: Activities for Learning*. New York: Metropolitan Museum of Art.

1. How many reflections can be found in the figure? Sketch and label each line of symmetry.
2. How many rotational symmetries can be found in the figure? List each rotation by degrees.
3. Draw two squares by using lines to connect intersections in the figure.
4. How many triangles can you create from connecting intersections in the figure?
5. What is the diameter of each circle (in centimeters)?
6. Calculate the area of one circle.
7. Approximate the area of the entire figure.
8. Describe how you might add to the figure to complete the flower in the center of the design.
9. Determine how many figures you would need to create a border as pictured on a 10 meter wall.



### **Part 3. Geometric Figures.**

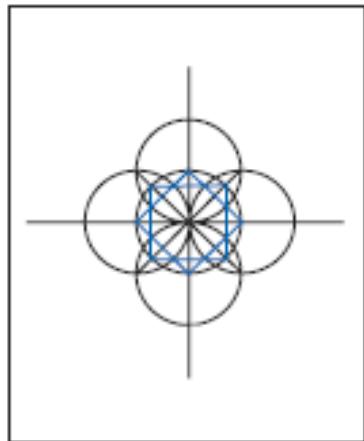
Using the five overlapping circles you created in Part 2, find the geometric figures most commonly found in Islamic art. You should copy each shape on a separate sheet of paper. However, you may trace your original five overlapping circles for each subsequent figure. Follow the directions below to sketch each shape, and then look for other ways in which you might form various shapes using the circles.

### **Part 4. Assessment.**

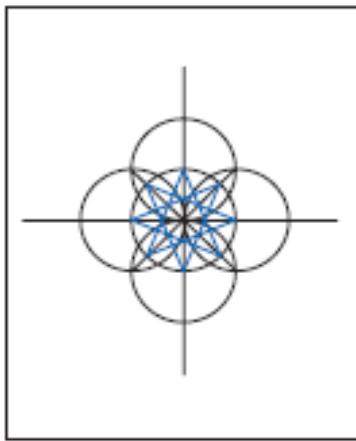
Design your own pattern using circles and other geometric shapes formed within them. In a paragraph, describe the symmetries of your design and use the template to create a colorful wall pattern or a border on construction paper.

**Eight-pointed star:**

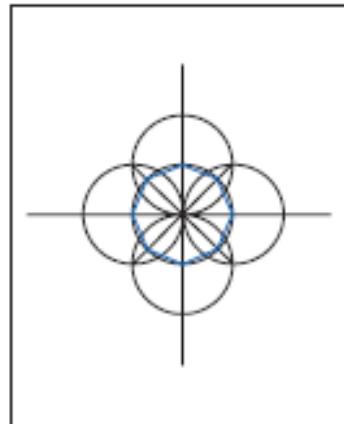
a) By joining every second point on the original circle, you will create two squares that overlap to form an eight-pointed star.



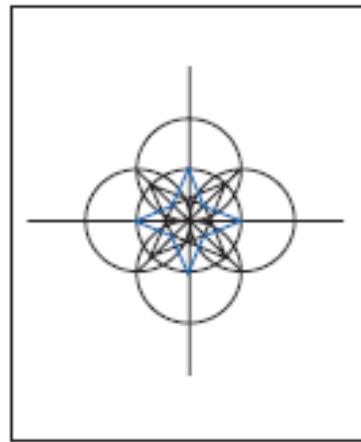
b) By joining every third point, you will create a different eight-pointed star.



**Octagon:** To create a regular octagon, use a straightedge to join adjacent points on the circumference of the original circle.



**Four-pointed star:** Embedded in the eight-pointed star (b) is a four-pointed star.



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### **TEACHER NOTES/SOLUTIONS**

**Part 1.** Lead a discussion allowing students to share what they have researched. Make sure that they understand the important ideas. Show slides of examples of Islamic art. Display the patterns the students created around the room at the end of the activity.

**Part 2.** 1. 8 lines of symmetry 2.  $90^\circ, 180^\circ, 270^\circ, 360^\circ$  3. answers may vary 4. answers may vary 5-9. will depend on each student's drawing, Use an example to review how you would find the answers and allow students to correct their mistakes. Then check students' answers after they have completed the activity for a grade.

*Example:* 5. A student creates the image using circles with diameter equal to 5cm. 6. Area of one circle=  $25\pi$  7. Approximate area of entire image= four circles – one circle (their approximate intersection) =  $75\pi$  8. One way is to duplicate the four overlapping circles and overlay them on the original image rotated  $45^\circ$  from their original position. This would create four more “petals” in between the pre-existing ones. 9. At a diameter of 10cm each, the design would have to be copied 100 times to border one side of the 10 meter wall.

**Part 3.** Review traditional shapes to ensure that each student understands the objective. Allow students to share their unique shapes or methods by presenting them to the class.

**Part 4.** Grade the assessment based on correct analysis of the design and understanding of the general concept expressed in the paragraph.

Rubric for Assessing Design and Paragraph:

Category	Score	Description
No Response	0	Design and analysis paragraph are not attempted, incorrect, irrelevant or do not go beyond restating the prompt.
Minimal	1	Demonstrates only minimal understanding of symmetry. The response is incomplete or contains major errors.
Partial	2	Contains evidence of understanding, but is not well developed. Displays some correct mathematics but may fail to illustrate it clearly in the design.
Satisfactory	3	Demonstrates a clear understanding of symmetry. Generally well developed and well presented, but contains some omissions or minor errors.
Excellent	4	Demonstrates a complete understanding of symmetry and how it is applied to geometric art. Methods for finding and creating symmetries are appropriate and fully developed. Response is logically sound, clearly written and has no significant errors. Design clearly illustrates the mathematical concepts studied.