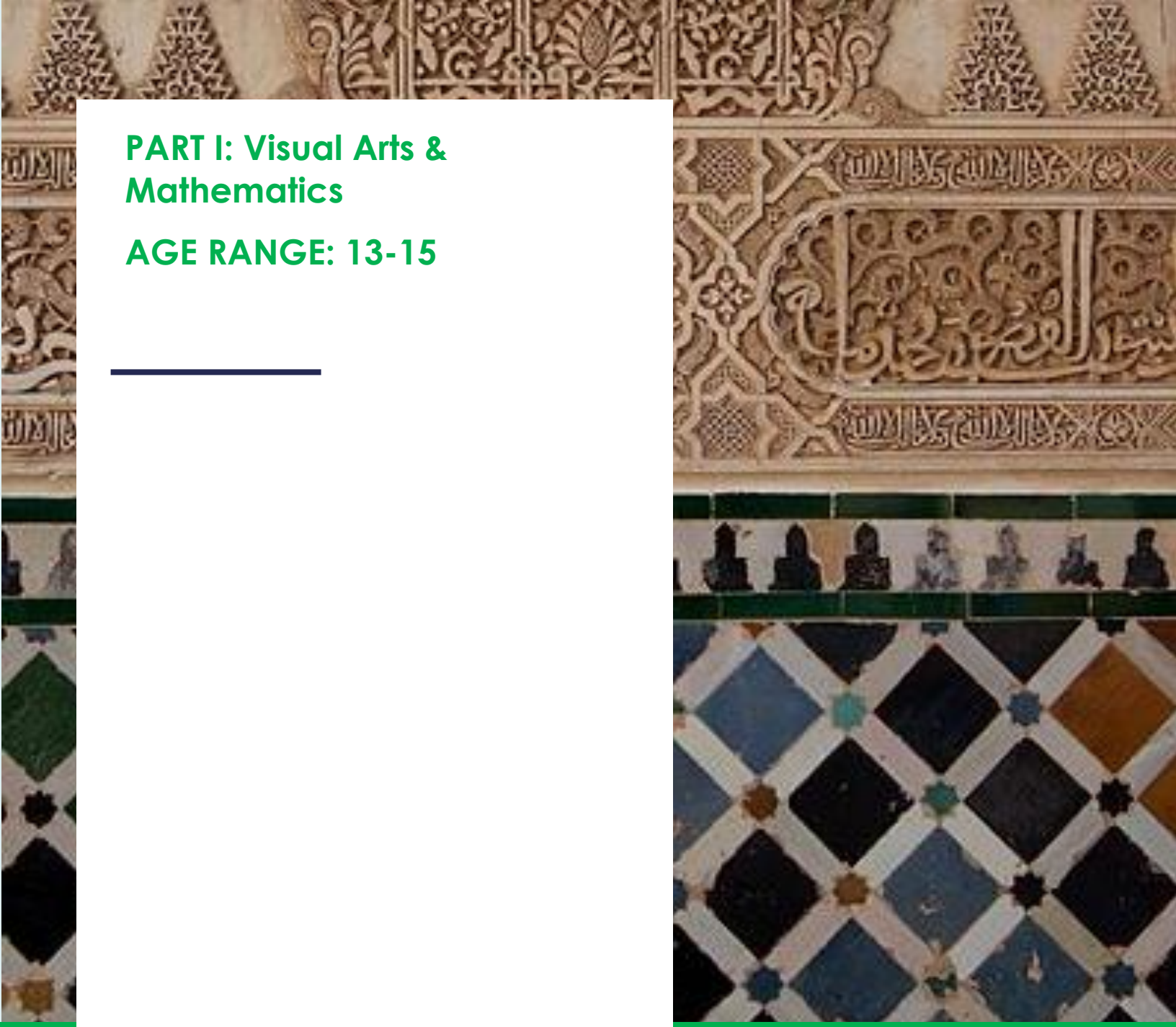

PART I: Visual Arts & Mathematics

AGE RANGE: 13-15

TOOL 2: ISLAMIC ART AND GEOMETRY

LogoPsyCom

TheArtOf Maths

Co-funded by the Erasmus+ Programme of the European Union

Educator's Guide

Title: Geometry in Islamic Art

Age Range: 13-15 years old

Duration: 2 hours

Mathematical Concepts: dimensions in space, symmetry, polygons, geometric relations, geometric transformations in a plane, cartesian coordinates

Artistic Concepts: Islamic Art, artistic patterns, tessellations, abstract art

General Objectives: To discover the mathematical concepts hidden in Islamic artistic compositions and understand the practical use of math through these explorations.

Instructions and Methodologies: The students will explore both fields as a whole, by drawing the art or watching the suggested videos that analyze Islamic artistic compositions. This tool is a basis to discover the mentioned math concepts.

Resources: This tool provides pictures and videos for you to use in your classroom. The topics addressed in these resources will help you find other materials to personalize and give nuance to your lesson.

Tips for the educator: Learning by doing is very efficient, especially with young learners with learning difficulties. Provide a hands-on experience for a more enjoyable experience and encourage creativity.

Desirable Outcomes and Competences: The student will be able to:

- Understand the different concepts of plane geometry;
- Understand how polygons were used in Islamic Art;
- Use cartesian coordinates to draw on a plane.

Debriefing and Evaluation:

Write 3 aspects you liked about this activity:	1. 2. 3.
Write 2 aspects that you have learned	1. 2.
Write 1 aspect for improvement	1.

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Introduction

The Middle Ages were an amazing time for Islamic Art to flourish. Many of the buildings that are still visited today, such as the Alhambra, come from that artistic current. In Islamic Art, we can actually see the connection with mathematics as the shapes represented are usually geometrical shapes with a mathematical reflection behind.

This type of art avoids the representation of living figures as it is considered as an exclusively divine activity to create living beings. This is why geometric shapes and calligraphy were two of the most widely used patterns in Islamic Art. Geometric knowledge could decisively be conceived as a theoretical instrument in visual arts.

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Islamic Art

According to the founding story, the principles of Islam were revealed to Muhammad, a merchant in Mecca in ca. 570–632 A.D. The Muslim scripture was called the "Qur'an", and their god "Allah". The name of this religion comes from Arabic and means "submission" (to Allah). Even though there were initially no rules against the use of figural representations in art, the Qur'an and the traditions were both against idolatry and the worship of images, and it was considered a sin.
There are some recurring images in Islamic Art: calligraphy, vegetal motifs, and geometric patterns. The geometric art was started by the Byzantine and Sasanian empires, but Islamic artists took it to another level, making it more rational and orderly. Islamic mathematicians and other scientists were involved in this process, bringing a fresh view on this art and on the scientific and mathematical concepts of those times.

As the circle is one of the main geometric forms used in Islamic art, the compass and the ruler were both widely used by artists. The repetition and combination of geometric shapes was the foundation of this art. The representations were mainly two-dimensional with no depth at all. There is usually a background and a foreground which are filled as much as possible with a pattern of combined shapes. Islamic art is also free in terms of space. It does not belong in a frame as it is made to always expand.

Islamic Geometry

As the representation of living figures was considered a sin, muslim artists used geometry to express their creativity. They designed complex patterns of geometrical forms that were tipically repetitive and seemed infinite, which aimed at representing the greatness of Allah's creation. The circle, considered as the perfect infinite shape, as well as the eight-pointed star were often used as a basis to build other patterns. This is why artists used a ruler and compass to build their works. Islamic geometry was used to decorate furniture, rugs, houses, and other buildings such as mosques.

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The star was a recurring image used in Islamic art, along with other shapes that fill the artworks' tesselations. Here are some examples:

- The Six-pointed Star and the Hexagon

Figure 1: Islamic Tile, six-pointed star

This tile is exposed at the Metropolitan Museum of Art in New York but comes from Iran and was created in the 13th-14th centrury. You can see that the stars are actually made of two **overlapping equilateral triangles**, which allows for such symmetry. Between the stars, there is another shape: the hexagon, which was also widely used in islamic art.

- The Eight-pointed Star

Figure 2: Islamic Tile, eight-pointed star

This tile, from the 13th century, is also exposed at the MET, in New York. The shape is one of the most common ones observed in Islamic geometric patterns. It contains several types of ornaments often seen during that period: geometry, vegetal motifs and calligraphy. As you can see, the eight-pointed star is actually made of **two overlapping squares**.

- The Twelve-pointed Star

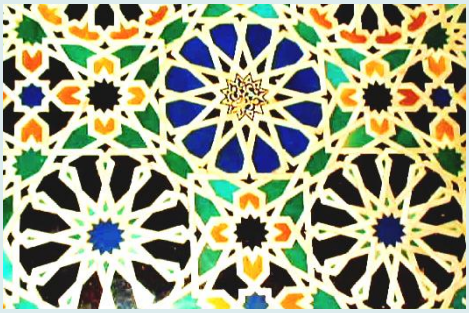

Figure 3: Islamic Mosaic, twelve-pointed star

This image shows a mosaic in the Alhambra, one of the most famous muslim palaces from the Middle Ages which is located in Southern Spain. As you can see, many different geometrical shapes fill every corner of this pattern. One of them is the twelve-pointed star. You can learn the technique's details by watching the following video:

https://www.youtube.com/watch?v=pg1NpMmPv48&feature=youtu.be

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You can use this fun tool to design your own tiles online. Use a computer or download the app on your phone to create as many designs as you want: https://tilemaker.teachalmasdar.com/.

Glossary

The Qur'an: the religious text of Islam that Allah revealed to the prophet Muhammad. Its name means "the recitation" in Arabic.

Islam: the Muslims' monotheist religion based on the sacred texts of the Qur'an.

Abstraction: is the use of lines, shapes, forms and colors that differ from the accurate depiction of the real world in visual art.

Tessellation: is when a shape or image repeats itself infinitely on a plane.

Calligraphy: the art of decorative writing.

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The Math behind Islamic Art

1. Planes:

First, let's see some geometry concepts:[1]

You know there are different dimensions for a geometrical shape:

- The **point** has a position but no dimension
- The **line** is one-dimensional
- The **plane** is two-dimensional
- The **solid** is three-dimensional

Islamic art is mostly two-dimensional, which means that it uses plane geometry. It is thus a representation of different shapes **on a flat surface that can extend infinitely**.

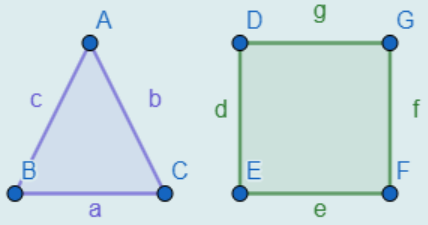
2. Polygons

In Islamic art, you will find many different figures in the infinite tessellations. Among these figures, you will see many **polygons**.

A polygon is a **two-dimensional** shape made of at least **three straight lines** and **angles**.

Among them, we can cite triangles, rectangles, pentagons, pentagrams and hexagons.

The word "polygon" comes from the Greek "polugōnon", which means "many-angled".



[1] https://www.mathsisfun.com/geometry/

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3. Transformations

To create tessellations and other visual effects, the artists sometimes use geometrical transformations:

- Rotation

Rotation occurs when you turn a shape around a point, the **center**, which is always at the same distance from any point of the shape.

You will need to choose the degree of rotation and use your protractor and compass:

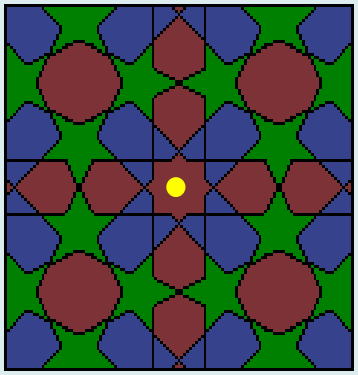

Figure 4: Illustration of rotation in an Islamic pattern

The yellow point is the center around which the shapes can rotate to create this symmetry. The different shapes turn with different degrees of rotation.

- Reflection

Reflection is what creates symmetry with a central line in the middle. Every point of the shape will be at the same distance from the line as its reflection.

Let's see an example:

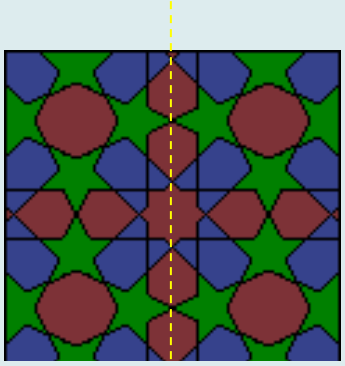

Figure 5: Illustration of reflection in an Islamic pattern

In this image, you can see that the middle of the picture is the central line that divides it into two perfectly identical images.

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- Translation

Translation is when you move a shape to another place by moving every one of its points in the same direction and at the same distance.

Let's see how this can be done:

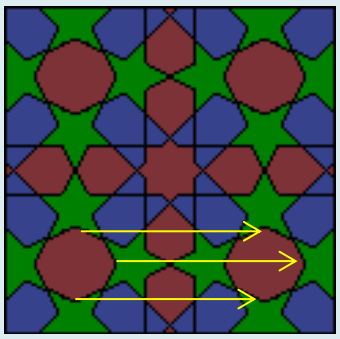


Figure 6: Illustration of translation in an Islamic pattern

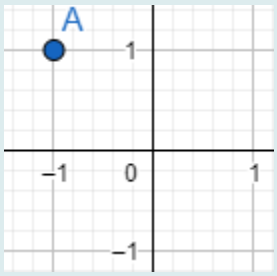
In this image, you can also see that it is possible to move a shape to a different place by moving its points:

- in the same direction
- at the same distance.

4. Cartesian Coordinates

Cartesian coordinates show us the place of a point on a graph. There are two axes:
Axis x, **the abscissa**, which tells you how far along the point is
Axis y, **the ordinate**, which tells you how far up it is

We always measure the position from the point O, **the origin**.
The coordinates of a point will be written as such: **(x,y)**



On this graph, the point A has the coordinates (-1,1) because we always measure the position from the origin, which is at the intersection of both axes.

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Remember when we talked about two-dimensional geometry?

Well, think about this:

- In a number line, you can only go left – right
- In a graph, you can go left – right and down – up
- In real life, you can do all that but also go backwards – forwards.

This is exactly what we saw with the three dimensions, which means that the graphs with cartesian coordinates can be used to represent two-dimensional geometry, and thus Islamic art!

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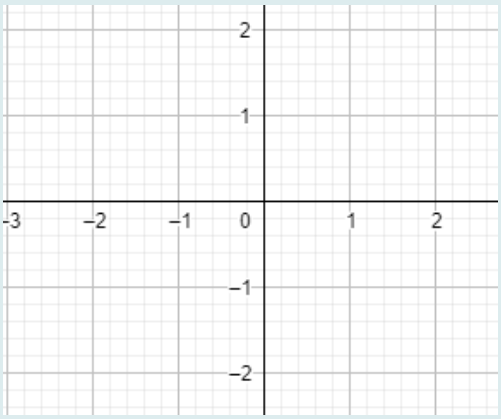
TASK

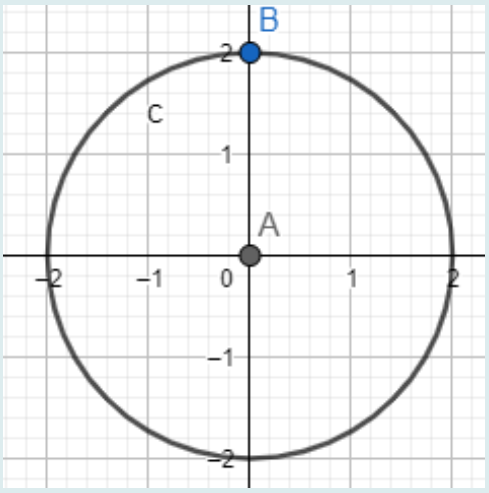
This task will enable you to comprehend the ways in which geometry was used in Islamic art.

To build such patterns, you will need to draw them on a plane.

The six-pointed star.



- Draw the axes
- Place your compass at the intersection
- Place point A at (0;0), the origin
- Place point B at (0;2)



- Open your compass by 2cm
- Draw a circle from center A

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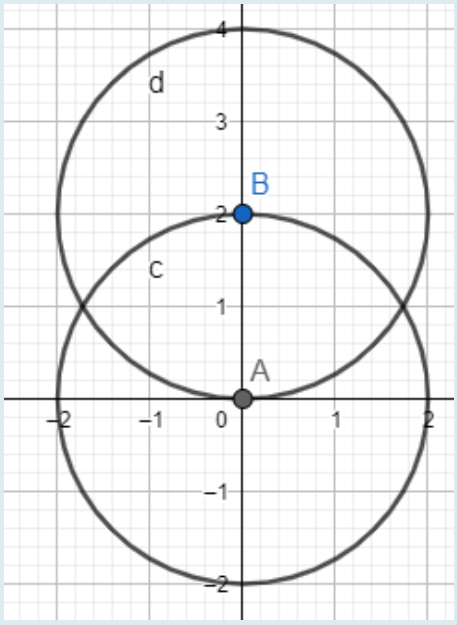
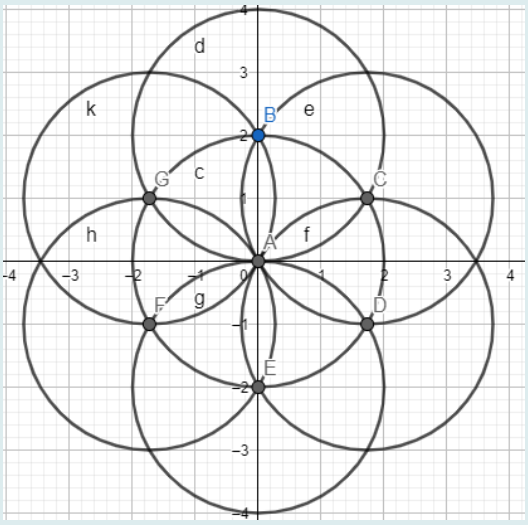
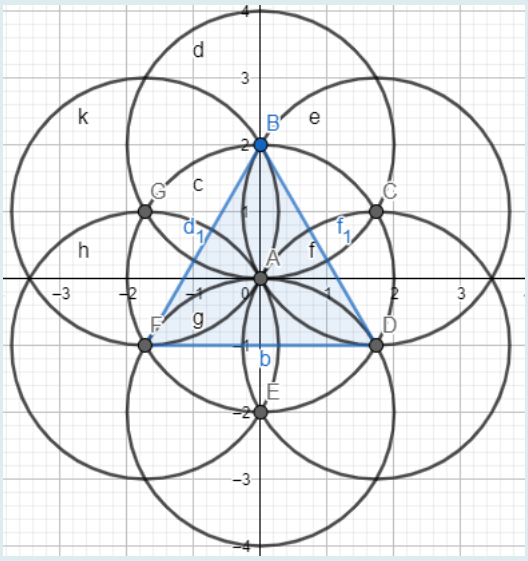


- Keep the same opening
- Draw another circle with your compass' needle point at point B
- Place point C at the intersection of the two circles
- Trace a circle from point C
- Place point D at the intersection of that circle with the original circle



- Repeat this with the following intersection of the circles with the original circle.



- Draw a triangle from point B to points F and D.
- Draw another triangle from point E to points G and C.
- Color the shape formed by the overlapping triangles

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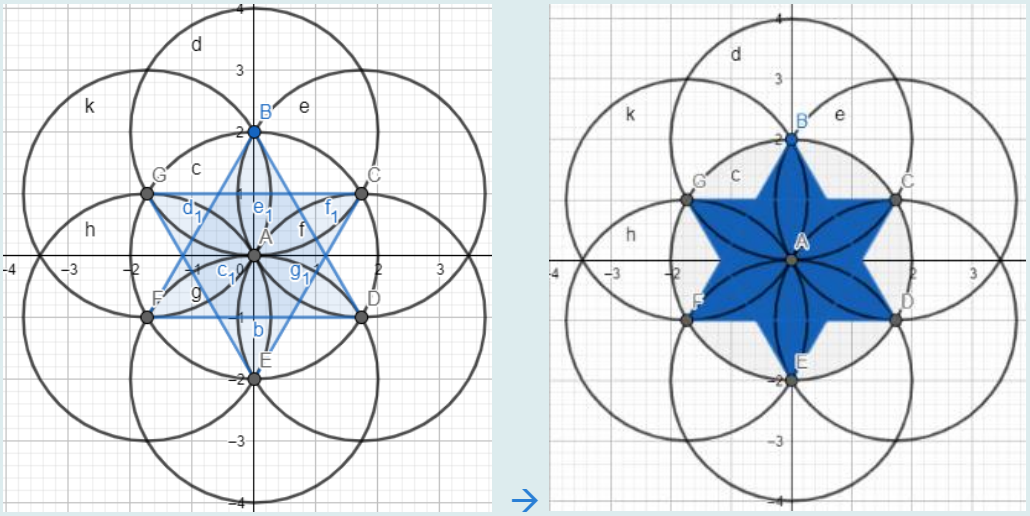
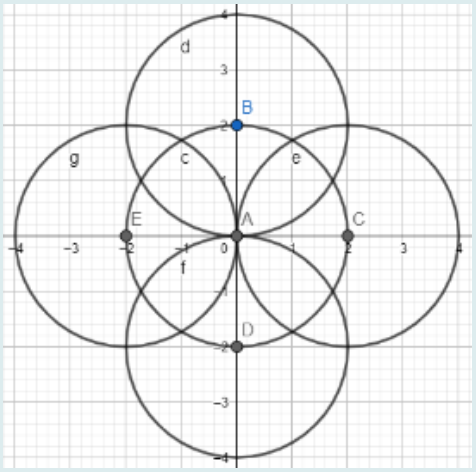


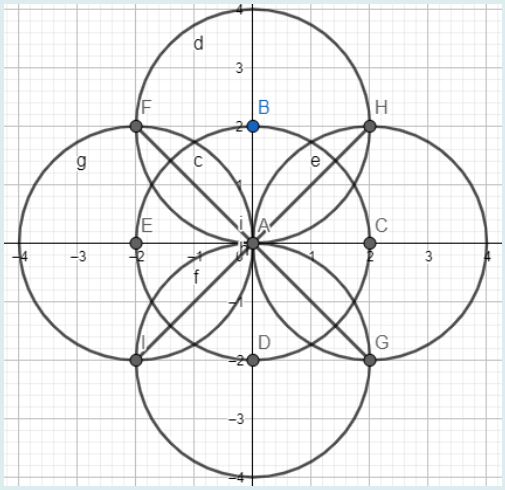
The eight-pointed star.

You can start the same way as with the six-pointed star.



- Draw a circle from every intersection of the first circle with the axes:

→ Place point B at (0;2)
→ Place point C at (2;0)
→ Place point D at (0;-2)
→ Place point E at (-2;0)



- Draw two lines linking the opposite intersections of the outer circles.

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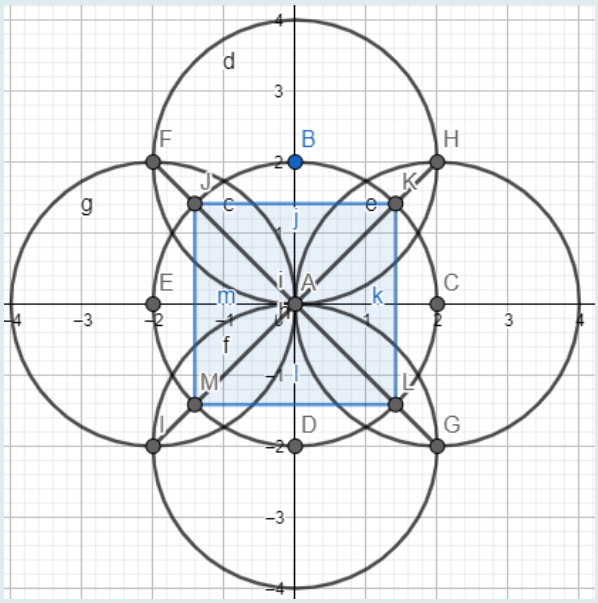
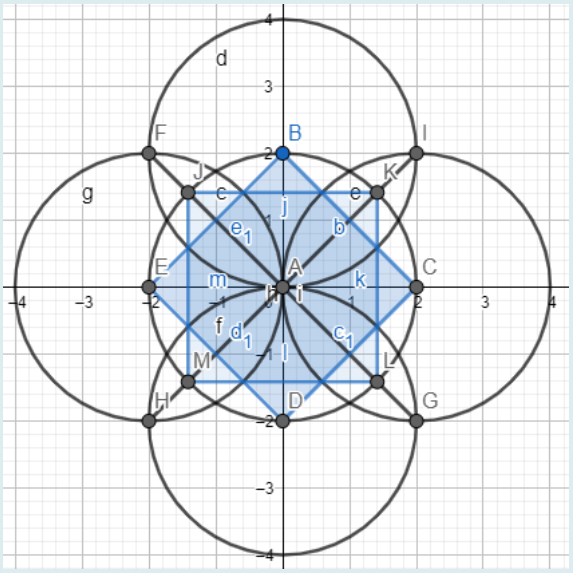
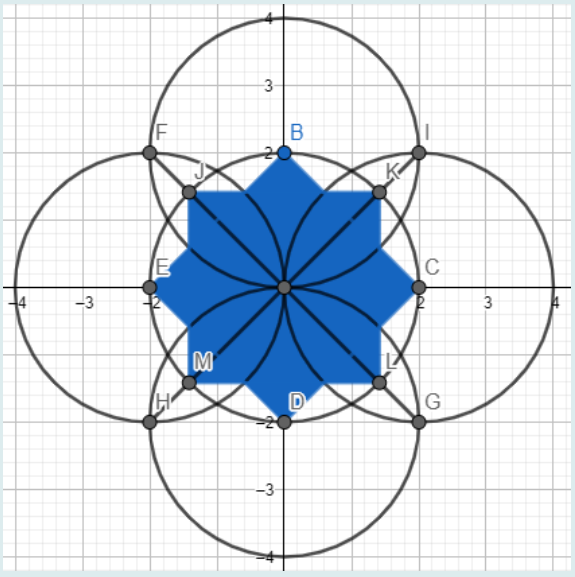


- Draw a first square linking the intersections of those lines with the original circle.
- Draw another square linking the intersections of the axes with the first circle.
- Color the shape formed by the overlapping squares





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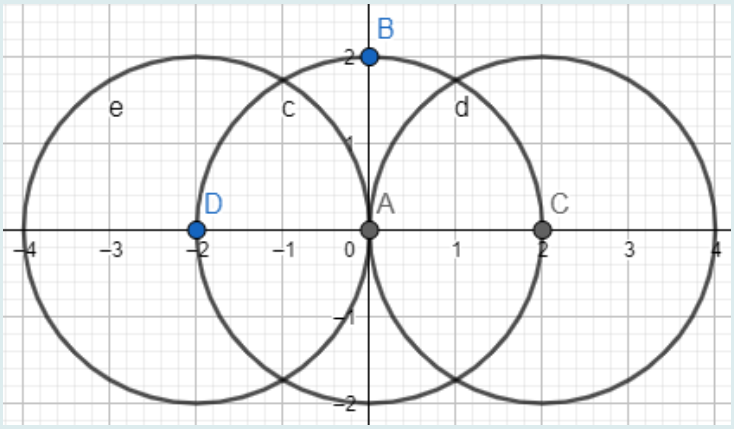
The twelve-pointed star

Let's try to make things a little more challenging!



- Place your compass' needle at the intersections of the first circle with the abscissa
- Draw three circles on the abscissa using the first one's center, point A and its intersections, points C and D

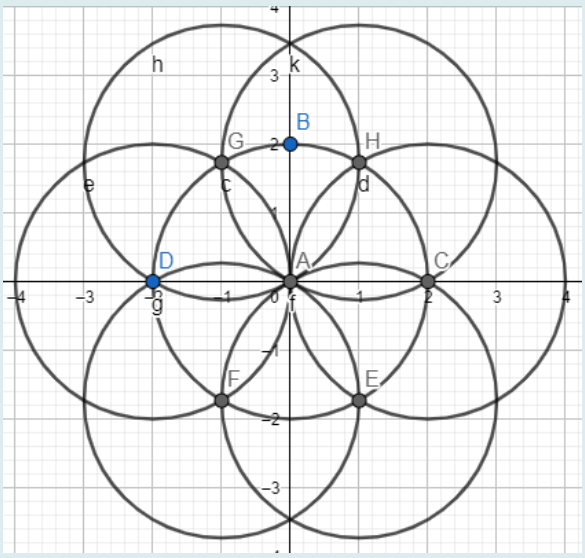
→ Place point B at (0;2)

→ Place point C at (2;0)

→ Place point D at (-2;0)

→ Place point E at (0;-2)

- Draw a circle from B and E
- Draw a circle from each circle's intersection with the first circle.



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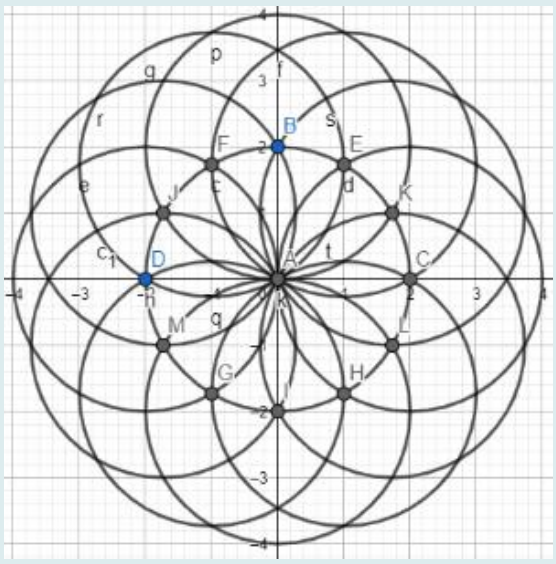

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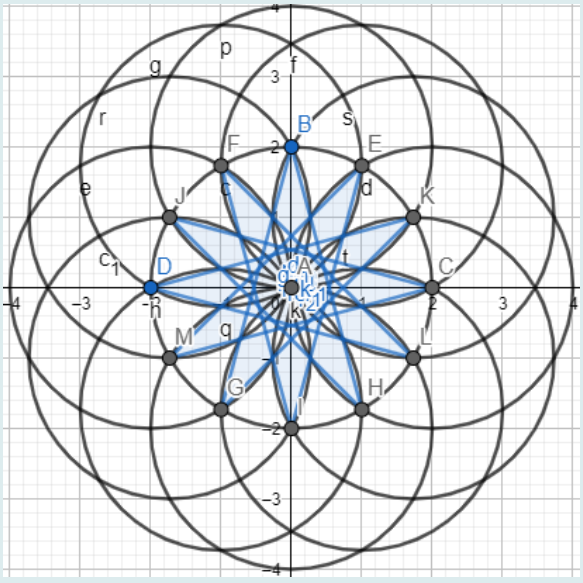
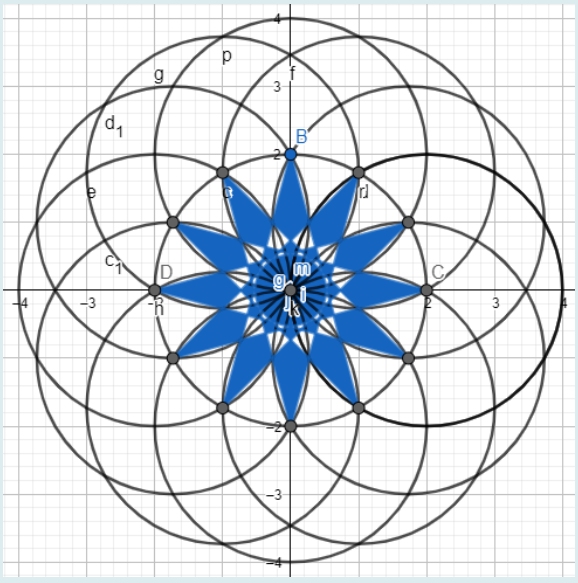
- To draw the star, link each point with the **fifth following point**.

→ Link point B to point H

→ Then H to J,

→ Then J to C…





Can you see that there are actually several twelve-pointed stars in the drawing?

If you prefer using a computer, you can draw the stars on a software called **GeoGebra**!

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LEARN MORE...

Learning activities with Islamic art:

https://www.metmuseum.org/-/media/files/learn/for-educators/publications-for-educators/islamic_art_and_geometric_design.pdf

History and activities about Islamic art:

https://www.ncetm.org.uk/resources/18030

Learning activities with Islamic art:

https://www.philamuseum.org/doc_downloads/education/lessonPlans/Common%20Core%20Math%20And%20Islamic%20Art.pdf

Lesson on the geometry of Islamic design:

https://www.youtube.com/watch?v=pg1NpMmPv48

Lesson on Islamic Art:

https://www.khanacademy.org/humanities/art-islam/beginners-guide-islamic-art/a/arts-of-the-islamic-world

Lesson on vectors to go further about translation:

https://www.youtube.com/watch?v=ml4NSzCQobk

Learning activities with Islamic art:

https://www.vam.ac.uk/info/teachers-resources-for-secondary-schools-and-colleges

Lesson about geometry in Islamic art:

https://artofislamicpattern.com/resources/educational-posters/

Two games/apps around Islamic art patterns:

http://www.engare.design/ or https://tilemaker.teachalmasdar.com/

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