

# Where do we see geometry in Islam? Geometry teaching pack



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# **GEOMETRY ACTIVITIES**

# **ENQUIRY OF LEARNING** Where do we see geometry in Islam?

The six activities in this pack have been developed to explore with students the intricate geometry that is found in Islamic culture, particularly in mosques and on tiles, carpets and pottery, and in Islamic architecture. They can be used to support learning about shape, tessellation and rotational symmetry in maths, as a stimulus for learning in art or to teach geometry as a standalone activity. They could also be used to introduce students to the principle of Geometry. You can find out more about Nature's principles of Harmony on The Harmony Project website.

The geometric patterns that are such a distinctive element of Islamic art and design are not just pleasing to look at; they also convey meaning. For Islamic artists, these patterns show the order of the world and the harmony that exists within it. By creating these designs, they are showing the perfection of God's creation.

For each activity, step-by-step instructions are provided as a guide for teachers, with accompanying diagrams and lists of the resources students will need to complete each activity. There are also photocopiable templates – where these are used, each student will need a copy to complete each activity.

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### COMPASSES

The activities in this pack can be adapted so that there is no need to use a compass to complete them by using the templates provided at the end of each activity. However, if you would like your students to engage in more of the geometric construction, Jakar compasses will help ensure accuracy and are easy to use. The can be purchased at a discount through The Harmony Project website.



### > WHY GEOMETRY?

Learning the geometry of Nature provides students with a new way of looking at the world. The observational skills and careful drawings that are required to recreate this geometry can have a powerful impact on students' understanding of Nature and their place in it. If we are to create a sustainable future, we need to see the world through a different lens, to understand that the patterns of life that exist around us also exist in us. This way of seeing the world means we view everything from a place of connection, rather than separation. This sense of connection is an essential part of learning to live sustainably. After all, the word 'Harmony' means joined or connected.

# **GEOMETRY ACTIVITY 1**

## **ENQUIRY OF LEARNING** Where do we see geometry in Islam?

# LEARNING QUESTION How can I draw an Islamic pattern using a grid?

This activity can be used to explore tessellation in maths or could be the starting point for an art project to create a design for a tile inspired by Islamic art.

In this activity, students use a grid template to create a tessellating tile design, which can be duplicated and used to build up a more detailed design for wall or floor decoration. To take the activity further, once students have used the grid to create a basic tile design, they can add additional embellishment, using images of Islamic tiles for inspiration.

Eye-catching geometric patterns, such as the one students will create in this activity, are often seen on the walls and ceilings of mosques, palaces and other buildings. These patterns help to create a sense of peace, calm and order.

#### YOU WILL NEED

Copies of Resource 1A Ruler HB pencil Good-quality eraser Coloured pencils Scissors



Tiles at the Alhambra palace in Granada, Spain

### DID YOU KNOW?

Islamic geometric patterns can be created using a grid. Imagine a piece of paper with lots of small squares or rectangles. The lines in the grid are there as a guide to show where to put the shapes. Different shapes, such as triangles, squares and stars, are drawn inside the squares on the grid and then repeated and combined to make beautiful designs. Many of the tiled patterns found at the Alhambra palace in Spain are based on square grids and cover large areas of wall.



# **ACTIVITY 1**

# STEP 1 Familiarise yourself with the template

Start with a printout of Resource 1A on A4 paper. It is a simple  $3 \times 3$  grid.

#### STEP 2 Draw the first cross

Use a ruler to draw a cross in the top centre square of the grid. This is made up of two diagonal lines running between the vertices of the square.



#### STEP 3 Draw the second cross

In the bottom centre square, draw another cross in the same way.

### **STEP 4 Add horizontal lines**

Add the horizontal lines shown in green below. They create a horizontal line break between the crosses.





#### STEP 5 Check the grid

The finished grid should look like this. It is a very simple construction that will come alive when colour is added.



#### **STEP 6 Add colour**

Follow the colour scheme shown below to colour in and reveal the pattern. Choose contrasting colours and, if working in a group, make sure everyone uses the same two colours. Use scissors to cut around the square, to create a tile.



#### STEP 7 Arrange the tiles

When you have drawn, coloured and cut out enough tiles, start to arrange them in a pattern. Begin with a tile with a horizontal band. Next to it, rotate another tile through 90 degrees, so the central band is vertical, and place it next to the first tile.

#### **STEP 8 Create a pattern**

Group four tiles together, alternating the horizontal and vertical lines. Do you see an interesting shape revealed in the centre where the four tiles meet? You can repeat this pattern to create a whole wall of tiles.





# PHOTOCOPIABLE RESOURCE 1A


# **GEOMETRY ACTIVITY 2**

# **ENQUIRY OF LEARNING** Where do we see geometry in Islam?

# LEARNING QUESTION How can I draw an Islamic eight-pointed star?

This activity can be used to support learning about shape and tessellation in maths, or as the starting point for an art activity focusing on the designs found on Islamic tiles.

In this activity, students use a compass to create their own template for a square tile design and explore the ways that circles and squares can interact. Alternatively, the activity can be simplified by using the template in Resource 2A and starting from Step 5.

To take the activity further, students can add additional embellishment, using images of Islamic tiles for inspiration. Each student's finished tile design can be duplicated and used to build up a more detailed design for wall or floor decoration.

### YOU WILL NEED

Ruler HB pencil Compass Good-quality eraser Coloured pencils Scissors Optional copies of Resource 2A



Panel of tiles at The Met museum in New York, made in Iran and dating back to 1260

### DID YOU KNOW?

The Islamic eight-pointed star is a symbol commonly found in Islamic art and architecture. It is formed by overlapping two squares to create an octagonal shape. This star represents balance and harmony, as well as the interconnectedness of all things in the universe.

In tiling, it can be interspersed with pointed cross shapes to create a pattern known as 'The Breath of the Compassionate'. The eight-pointed star looks like it is expanding or inhaling, and the cross looks like it is contracting.



# **ACTIVITY 2**

#### STEP 1 Draw the first circle

Draw a horizontal line across the centre of the page. From the centre of the line, use a compass to draw a circle with a radius of 7cm. Alternatively, print out the template on Resource 2A and follow the instructions from Step 5.



#### STEP 2 Draw two semi-circles

Use a dot to mark the points at which the horizontal line intersects the circumference of the first circle. Place the compass needle at each of these points in turn to draw two semi-circles, both with a radius of 7cm.



### STEP 3 Draw a vertical line

Mark the two points at the top of the diagram where the circumference of the circle intersects the two semi-circles. Place the compass needle on one of the intersection points and draw an arc over roughly the centre of the circle. Do the same on the other side. Where they form a cross is the central point. Repeat in the bottom half of the drawing. Use a ruler to draw a vertical line between the two cross points, bisecting the central circle.

#### STEP 4 Draw two further semi-circles

Mark the two points at which the vertical line cuts through the circumference of the central circle. Place the compass needle on each of these points in turn and draw two more semi-circles with the same 7cm radius. You should now have a pattern that looks like four petals, as shown below.





#### STEP 5 Draw an enclosing square

Use a dot to mark the outermost tip of each of the four petals. Connect these dots to draw a square.



# STEP 6 Add diagonal lines

Draw diagonal lines from vertex to vertex inside the square.



#### STEP 7 Draw a static square

Use a dot to mark the four points at which the diagonal lines you have just drawn intersect the circumference of the circle. Use a ruler to draw four lines joining these dots to create a square resting on one of its sides. This is known as a static square.



Now use a dot to mark the four points at which the vertical and horizontal lines intersect the sides of the enclosing square. Use a ruler to draw four lines joining these dots to create a square resting on one of its vertices. This is known as a dynamic square.





### STEP 9 Check the design

The finished pattern should look like this. It will come alive with colour and repetition.

#### **STEP 10 Add colour**

Colour the drawing to pick out the eight-pointed star. Begin by colouring in the octagon at the centre. Choose a different colour for the eight triangles that make up the points of the star. Finish by colouring the background of the tile in a complementary colour.





#### **STEP 11 Tessellate the tiles**

Cut out the completed tile and repeat Steps 1 to 10 to create three more. Lay out the four tiles as shown below, with their sides touching. What do you notice about the pattern? Does another shape emerge?



# PHOTOCOPIABLE RESOURCE 2A



# **GEOMETRY ACTIVITY 3**

### **ENQUIRY OF LEARNING** Where do we see geometry in Islam?

# **LEARNING QUESTION** How can I draw an Islamic pattern from the Alhambra?

This activity can be used to support learning about shape and tessellation in maths or to create Islamic surface decoration designs in art.

In this activity, students use a compass to create their own template for a geometric pattern inspired by Islamic surface decoration. Alternatively, to simplify the activity, or if compasses aren't available, the template on Resource 3A can be used. In this case, the instructions should be followed from Step 7 onwards.

# YOU WILL NEED

Ruler HB pencil Compass Good-quality eraser Coloured pencils Scissors Optional copies of Resource 3A



Pattern from the Alhambra palace in Granada, Spain

## DID YOU KNOW?

The Alhambra in Granada, Spain, is a centuries-old palace featuring amazing geometric designs. These patterns are made up of stars, polygons and other symmetrical shapes. The architects and artists who built the palace used these shapes to create beautiful and intricate designs. They believed that these patterns represented the balance and order in the world.

This pattern, shown left, is based on six-fold symmetry and has an underlying grid made up of overlapping circles.



# **ACTIVITY 3**

#### STEP 1 Draw the first circle

Draw a horizontal line across the centre of the page. From the centre of the line, use a compass to draw a circle with a radius of 4cm. Alternatively, print out the template on Resource 3A and follow the instructions from Step 7.



#### STEP 2 Draw two more circles

Use a dot to mark each of the two points at which the circumference of the circle intersects the horizontal line. Place the compass needle on each of these dots in turn and draw two further circles, each with a 4cm radius.



# STEP 3 Draw two circles below the first three

Use a dot to mark each of the two points at which the circumferences of the two circles you drew in Step 2 intersect the circumference of the first circle you drew in Step 1, at the bottom of the diagram. Place the compass needle on each of these dots in turn and draw two further circles, each with a 4cm radius.

# STEP 4 Draw two circles above the first three

Repeat the process outlined in Step 3 but this time at the top of the diagram, as shown below.





#### STEP 5 Draw six semi-circles

Use a dot to mark each of the six points at which the circumferences of the six outer circles intersect on the outer edge of the design you have created. Place the compass needle on each of these dots in turn and draw six semi-circles, each with a 4cm radius, as shown below in green.



Use a dot to mark each of the six points at the outermost tip of the petals shown below. Again, all of these dots sit on the outer edge of your design. Place the compass needle on each of these dots in turn and draw six arcs, each with a 4cm radius, as shown below in green. Each of the seven circles that make up the diagram should now contain six petals.



#### **STEP 7 Colour the central petals**

Start adding colour to your design. Colour the six petals in the central circle first.

#### STEP 8 Colour the first wave shape

Use a contrasting colour to colour the sections of your diagram that make up the wave shape shown below.





# $\label{eq:steps} \ensuremath{\mathsf{STEP}}\ensuremath{\,\mathsf{9}}\ensuremath{\,\mathsf{Colour}}\xspace$ the second wave shape

Use the same colour for the sections of the diagram that make up the second wave shape shown below.

# STEP 10 Colour the third wave shape

Complete the pattern by colouring the third wave shape, as shown below.





### STEP 11 Tessellate the tiles

Cut out your finished tile and create two more using the same colour combination. Create a further three using different colours. Fit them together so the colours alternate, as shown below.



# PHOTOCOPIABLE RESOURCE 3A



# **GEOMETRY ACTIVITY 4**

### **ENQUIRY OF LEARNING** Where do we see geometry in Islam?

# LEARNING QUESTION How can I develop a repeated pattern for a tile?

In this activity, students use rotational symmetry and the template on Resource 4A to create a design for a hexagonal tile inspired by Islamic art. This can support learning about rotational symmetry in maths or learning in art.

The students' completed hexagonal tile designs can be placed together in one large, striking class display or each student's tile design can be duplicated and the tiles placed alongside each other to create individual artworks for an exhibition.

#### YOU WILL NEED

Copies of Resource 4A HB pencil Good-quality eraser Tracing paper Masking tape Coloured pencils Scissors Optional copies of Resource 4B



Islamic floral cut tiles from Iran



Islamic flower patterns are beautiful designs that are often seen on tiles and other decorations in Islamic art. These patterns have a special kind of symmetry, as they are balanced and look the same on both sides. The flower shapes in the pattern are usually made up of repeated petals and circles. The symmetry of these designs reflects the Islamic belief in the harmony and order of the universe.



# **ACTIVITY 4**

#### STEP 1 Draw a floral design

Using the template in Resource 4A, create or copy a floral design that runs half the length of the central line of symmetry, as shown below. Alternatively, print out the template on Resource 4B and start from Step 2.



#### STEP 2 Add detail

If there is space, add some internal decoration. You might add shapes such as tear drops, which can be coloured in later on.



### STEP 3 Trace the design

Use tracing paper to trace the design you created in Steps 1 and 2. Turn the tracing paper over and line up the design with the side of the adjacent triangle, as shown below. Tape it down with masking tape and go over the design carefully with pencil to transfer it.

#### STEP 4 Add more detail

Add other elements to the first triangle, such as hearts or leaf shapes.





# STEP 5 Trace the design into the second triangle

Use tracing paper to trace the entire design you created in the first triangle. Turn the tracing paper over and line it up with the sides of the adjacent triangle, as shown below. Tape it down with masking tape and go over the design carefully with pencil to transfer it.



# STEP 6 Trace the design into the third triangle

Repeat the tracing process outlined in Step 5 to transfer your design into the third triangle.



# STEP 7 Trace the design into the remaining triangles

Repeat the tracing process until all the triangles are complete.

### STEP 8 Check the design

Check your design to make sure all the lines are clear and that they connect along the lines of symmetry. Go over any very faint lines in pencil and join up any elements of the design that don't fully connect.





#### STEP 9 Start to colour the design

Choose a colour for the six branches of the floral design, as shown below, and colour these in.

#### **STEP 10 Colour the details**

Use a complementary colour for the details.





#### STEP 11 Colour the background

Choose a darker background colour to contrast with the floral pattern and define the outer edges of the tile. When you have finished colouring, cut out the tile.

### STEP 12 Tessellate the tiles

Repeat Steps 1 to 11 to create two more tiles. Put the tiles together to see how the pattern looks when it repeats. You can create a whole wall of tiles.





# PHOTOCOPIABLE RESOURCE 4A



# PHOTOCOPIABLE RESOURCE 4B



# **GEOMETRY ACTIVITY 5**

# **ENQUIRY OF LEARNING** Where do we see geometry in Islam?

# LEARNING QUESTION How can I represent the cube and circles of the Kaaba?

This activity can be used to support learning about 3D shape in maths or as an introduction to 3D drawing techniques in art and design.

In this activity, students use a compass to create a template that they can use to complete a 3D drawing of a cube, which references the cube form of the Kaaba in Saudi Arabia. To simplify the activity, or to adapt it if compasses aren't available, the template in Resource 5A can be used; in this case, start following the instructions from Step 3 onwards.

# YOU WILL NEED

Ruler HB pencil Compass Good-quality eraser Coloured pencils Optional copies of Resource 5A



# ) DID YOU KNOW?

The Kaaba is a holy site in the city of Mecca, Saudi Arabia. It is shaped like a big cube and covered with a black cloth. It is a very important place for Muslims because they believe it was built by the Prophet Abraham and his son, the Prophet Ishmael, a long time ago. Every year, millions of Muslims from all over the world visit the Kaaba. They walk around it in a circle (this is called circumambulation) as a way to show their love and devotion to God.



# **ACTIVITY 5**

#### STEP 1 Draw the first circle

Draw a vertical line down the centre of the page. Place the compass needle on the line at roughly its central point and draw a circle with a radius of 5cm. Use a dot to mark each of the two points at which the vertical line intersects the circumference of the circle. Alternatively, print out the template on Resource 5A and follow the instructions from Step 3.



#### STEP 3 Draw a hexagon

Using a ruler, draw six lines to join the six dots and create a hexagon.

#### STEP 2 Draw two semi-circles

Place the compass point on each of these two dots in turn and draw two arcs with the same 5cm radius. Each semi-circle should intersect the circumference of the circle. Next, use a dot to mark each of these four points of intersection, as shown below.



#### STEP 4 Create a cube

Using a ruler, draw three further lines to connect every other dot to the centre point of the circle, as shown below in green. The three diamond shapes create the impression of a cube.





#### STEP 5 Draw an enclosing circle

Place the compass needle on the centre point of the circle and draw a second circle with a 6.5cm radius. This represents the circular movement of people around the Kaaba.

#### STEP 6 Draw a second enclosing circle

Repeat the process outlined in Step 5 to draw another circle, this time with a radius of 7.5cm.





#### **STEP 7 Draw a third enclosing circle** Repeat the process outlined in Step 5 to draw

another circle, this time with a radius of 8.5cm to complete the concentric circles.

#### **STEP 8 Add shading**

Bring out the 3D quality of the Kaaba by shading the top diamond, where the light falls, in a lighter colour than the other two sides. You could also draw tiny figures around the circles.





### PHOTOCOPIABLE RESOURCE 5A



# **GEOMETRY ACTIVITY 6**

# **ENQUIRY OF LEARNING** Where do we see geometry in Islam?

# **LEARNING QUESTION** How can I use tessellation to create a geometric pattern?

This activity can be used to support learning about shape and tessellation in maths or as the stimulus for an art project inspired by Islamic tile designs.

In this activity, students use the template in Resource 6A to build up their own hexagonal tile designs.

The students' completed hexagonal tile designs can be placed together in one large, striking class display. Alternatively, each student's tile design can be duplicated and the tiles placed alongside each other to create individual artworks for an exhibition.

#### YOU WILL NEED

Copies of Resource 6A Ruler HB pencil Compass Good-quality eraser Coloured pencils Scissors



Pattern from the Agra Fort in India

### DID YOU KNOW?

Islamic tessellating patterns are amazing designs made up of repeating shapes such as hexagons and kites. These shapes fit together perfectly, like puzzle pieces, with no gaps or overlaps. This example from the Agra Fort in India has interlocking rectangles that can sit around a hexagonal tile. When placed together, they create a flowing pattern that can cover an entire wall.



# **ACTIVITY 6**

# STEP 1 Familiarise yourself with the template

On the template on Resource 6A, take a moment to locate the 12 points at the centre of each of the sides and on each of the vertices of the hexagon.



### STEP 3 Draw the second triangle

Use a ruler to draw three lines joining the three points shown in green below to create a second triangle.

### STEP 2 Draw the first triangle

Use a ruler to draw three lines joining the three points shown in green below. What is the name of the triangle you have created. How do you know what it is? What are its properties?



#### STEP 4 Draw the third triangle

Use a ruler to draw three lines joining the three points shown in green below to create a third triangle.





#### STEP 5 Draw the fourth triangle

Use a ruler to draw three lines joining the three points shown in green below to create a fourth triangle.

#### STEP 6 Draw the first rectangle

Next, use a coloured pencil to go over the lines shown below to create three sides of a rectangle.





# STEP 7 Draw the second rectangle

Next, use a coloured pencil to go over the lines shown below to create three sides of a rectangle that sits on the adjacent side of the central hexagon

**STEP 8 Draw four further rectangles** Use a coloured pencil to go over three of the sides of four further rectangles, each of which sits on one of the sides of the central hexagon.





### STEP 9 Check the design

Make sure that the sides of the central hexagon and the sides of each of the smaller kite shapes at each vertex of the central hexagon are thicker than the other lines in the diagram and clearly visible.



#### STEP 10 Add colour

Choose three different colours to colour the central hexagon, kite shapes and background.



### STEP 11 Tessellate the design

Repeat Steps 1 to 10 to create two more identical hexagonal designs. Put the designs together to see how the pattern looks when it repeats.



# PHOTOCOPIABLE RESOURCE 6A



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#### SUSTAINABLE PRINTING

The Harmony Project is committed to working towards a sustainable future. With this publication, we are collaborating with Impress, a carbon balanced printer.

Full production of this publication is carbon balanced and the paper used is FSC certified and fully recyclable.

