SUBLIME SYMMETRY

The Mathematics behind De Morgan's Ceramic Designs

Reflective symmetry   Rotations   Angles

90°

This maths workbook belongs to:

....

SUBLIME SYMMETRY

WILLIAM DE MORGAN

What have you found out about William De Morgan?

....

....

....

....

....

....

....

....

....
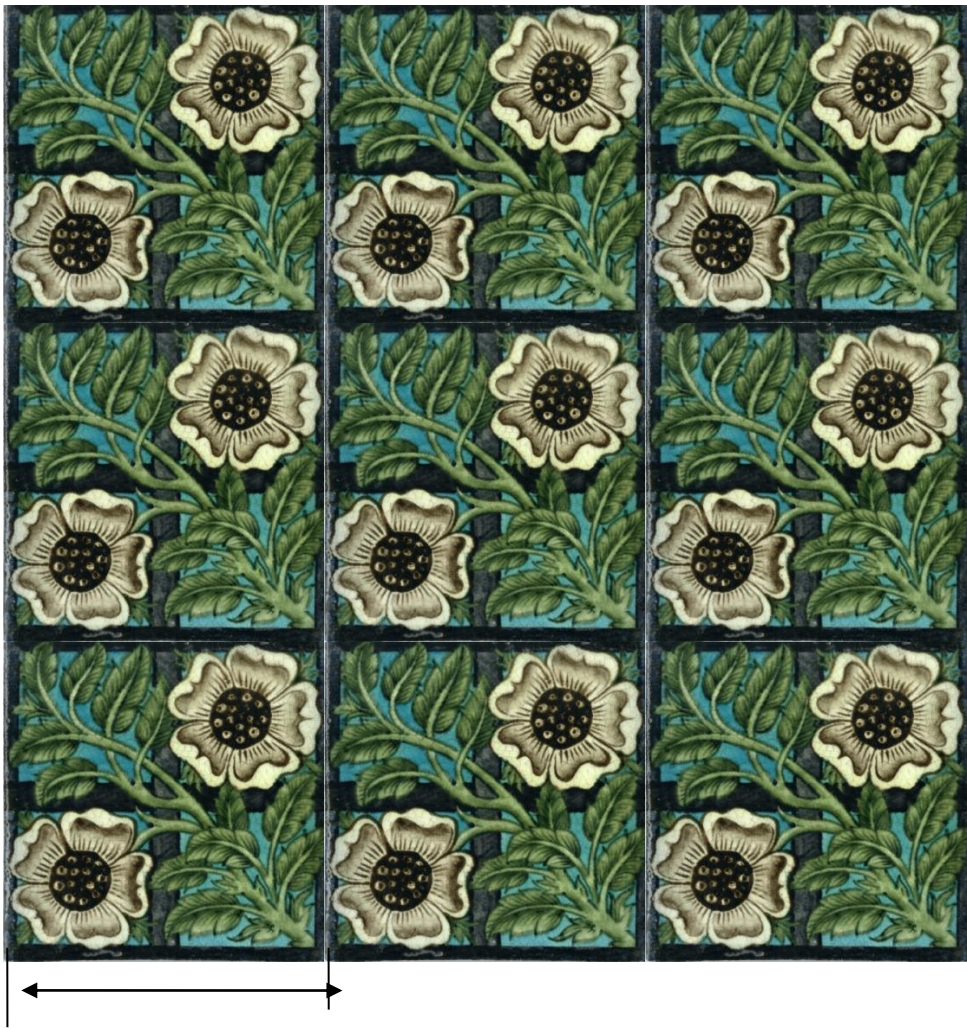
WILLIAM DE MORGAN'S DESIGNS

List all of the shapes you can see in each design.

SQUARES

This is William De Morgan's tile design *Rose and Trellis*. The design is made up of many squares.

A polygon is a shape made up of straight sides. Is a square a polygon?

.... cm

Use a ruler to measure the length of one tile of this design and fill in the blank space above.

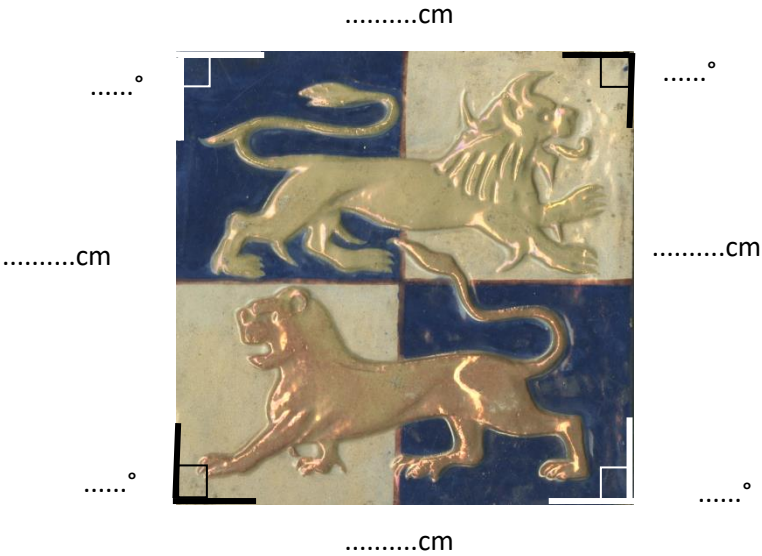How many tiles have been used in the design above?

Use this measurement to work out the

height ....cm and the area .... cm² of the design

SQUARES

- A QUADRILATERAL is a polygon with four sides.
- REGULAR POLYGONS have equal sides and equal angles.

..........cm

......°

..........cm

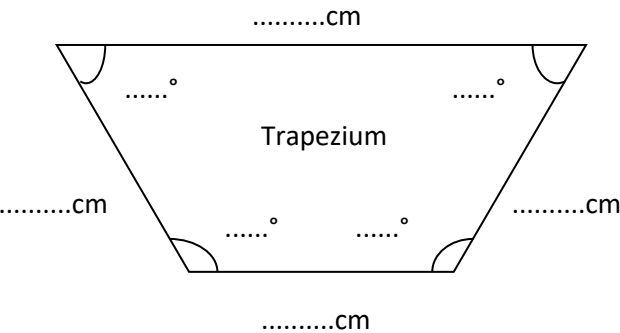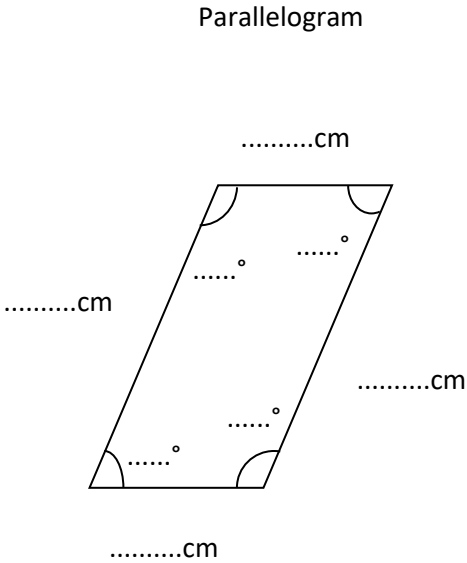..........cm

......°

......°

..........cm

......°

......°

..........cm

Measure the sides and angles of William De Morgan's *Heraldic Lion Tile* using a ruler and a protractor.

Is a square a quadrilateral? .... Is a square a regular polygon? ....

The angles you have measured in the square tile above are called right angles. A right angle measures ....°

Shapes that have four sides, which are not all equal, and angles that are not all right angles, are called IRREGULAR QUADRILATERALS.

Measure the sides and angles of these quadrilaterals to check whether they are irregular?

Parallelogram

..........cm

......°

......°

..........cm

..........cm

Rectangle

..........cm

..........cm

......°

......°

..........cm

..........cm

..........cm

Trapezium

......°

......°

..........cm

..........cm

......°

......°

..........cm

..........cm

SQUARES

William De Morgan once went on a boat trip down the River Thames. He wrote a story about it and joked about the hotel he stayed in, because it is called the Complete Angler. He said 'it is called so after an Angle of 360° in the immediate neighbourhood. We saw the Obtuse Angler standing there.'

An angler is another word for a fisherman, but De Morgan jokes that it sounds like an angle.

Measure the angles used to make up De Morgan's *Rose and Trellis* design.

......°   ......°

......°   ......°
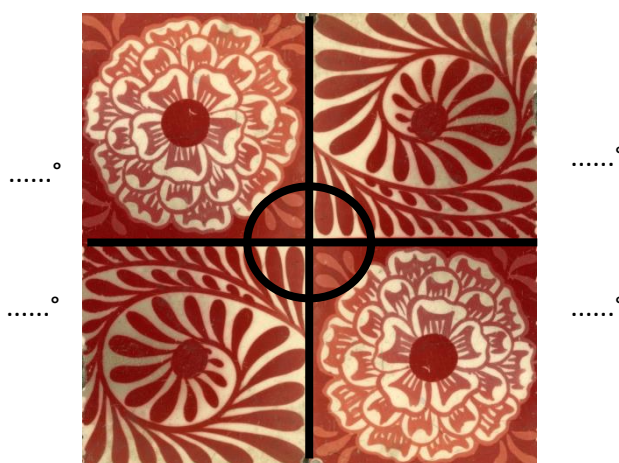
What do the angles inside the square add up to?

Why did William De Morgan joke that a 'complete angler' might measure 360°?

De Morgan says he saw an Obtuse Angler. An OBTUSE ANGLE is an angle bigger than a right angle of 90°. An angle smaller than a right angle is called an ACUTE ANGLE. Measure these angles and label them as acute angle, right angle or obtuse angle.

a) ....   b) ....   c) ....   d) ....   e)........................

WORKSHEET 4
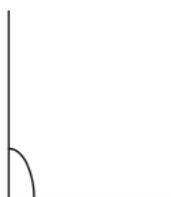
SQUARES

Use a ruler and a protractor to draw the outline of another four square tiles that will complete the tile pattern below.

Each tile is a square, so make sure that all of the sides of your squares have equal lengths and right angles in the corners, that measure 90°.

Try and draw in the flowers and the black swan design.
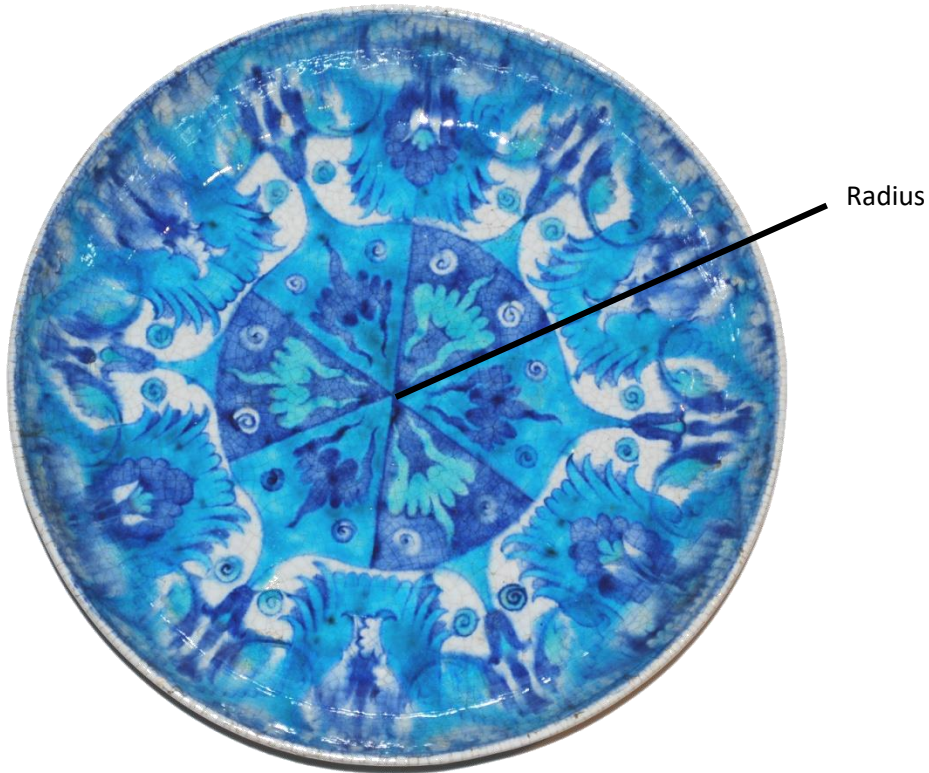
CIRCLES

SUBLIME SYMMETRY

There are many important features of circles which have been labelled below. Use this key to draw these features on William De Morgan's plate designs on the next page.

Radius

Diameter

Circumference

Tangent

Arc

Segment

Sector

90°

Right angle

360°

WORKSHEET 6
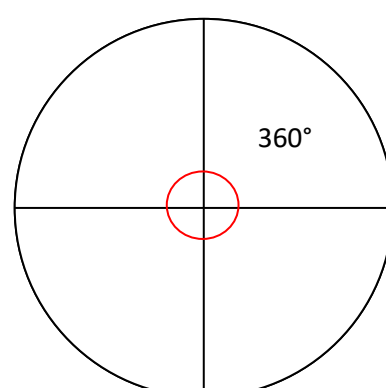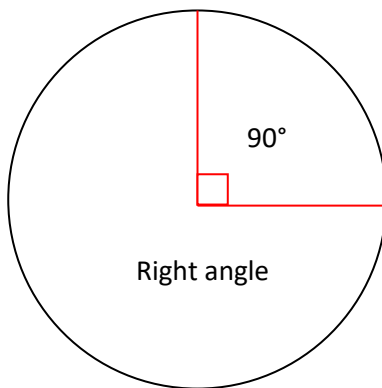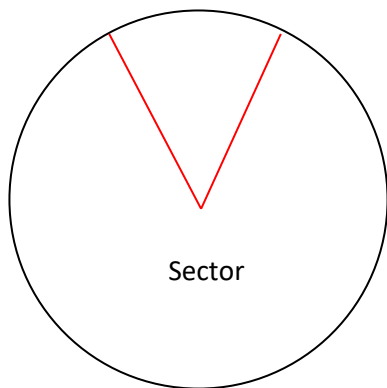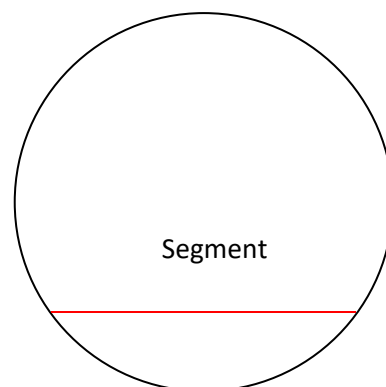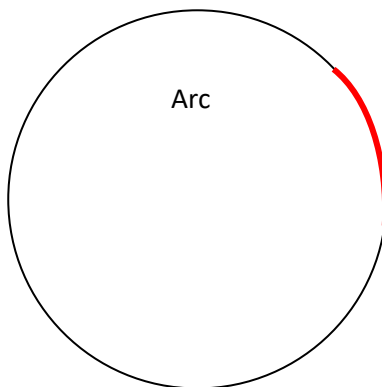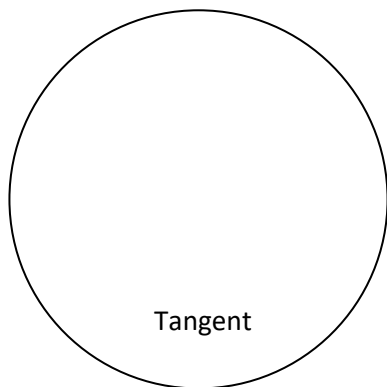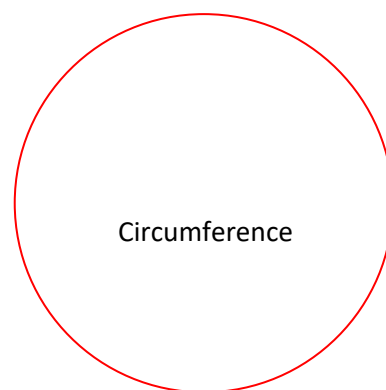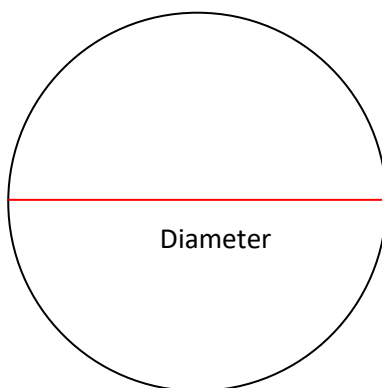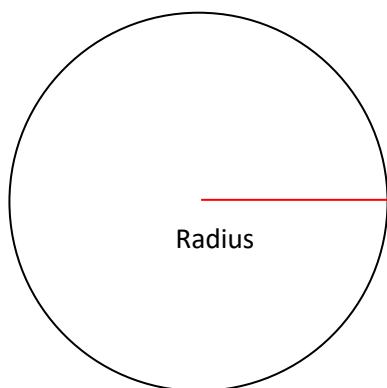
CIRCLES

Use the key to draw and label all of the properties of circles that William De Morgan has used in these designs.
Two have been done for you.

Radius

Arc

CIRCLES

SUBLIME SYMMETRY

Many of William De Morgan's designs for plates are designed around different sized circles.

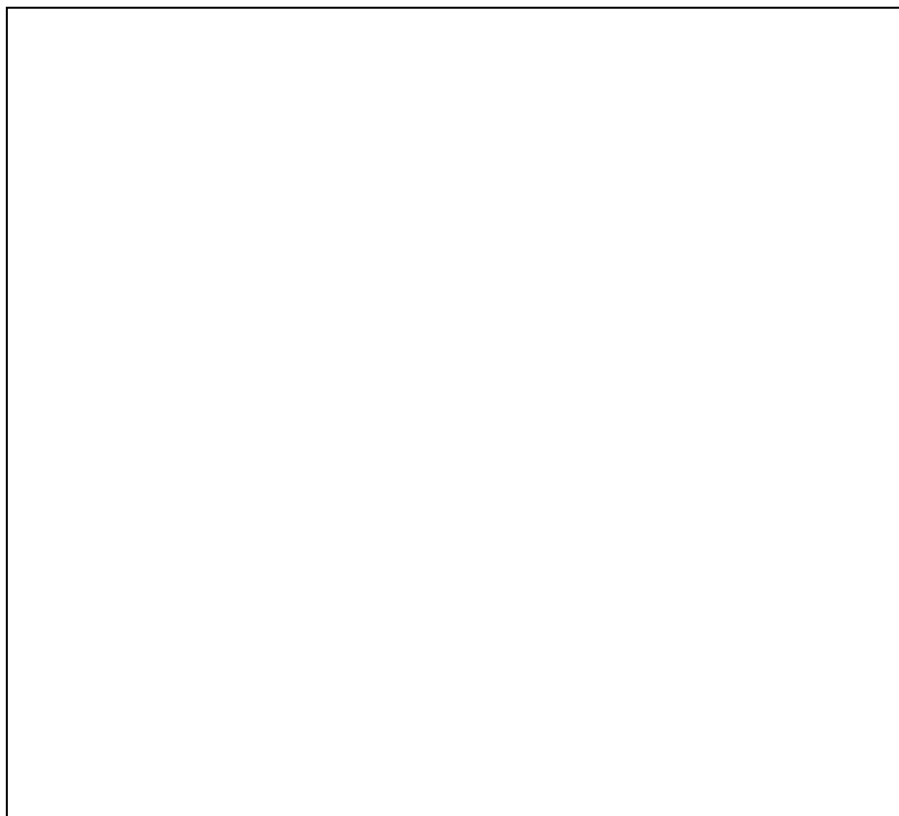How many circles are there in this design?

Measure the radius of the plate?

……………………………… cm

Measure the diameter of this plate?

……………………………… cm

William De Morgan would always decorate the backs of his plates with circle patterns. Can you use compasses to design a reverse pattern for this plate?
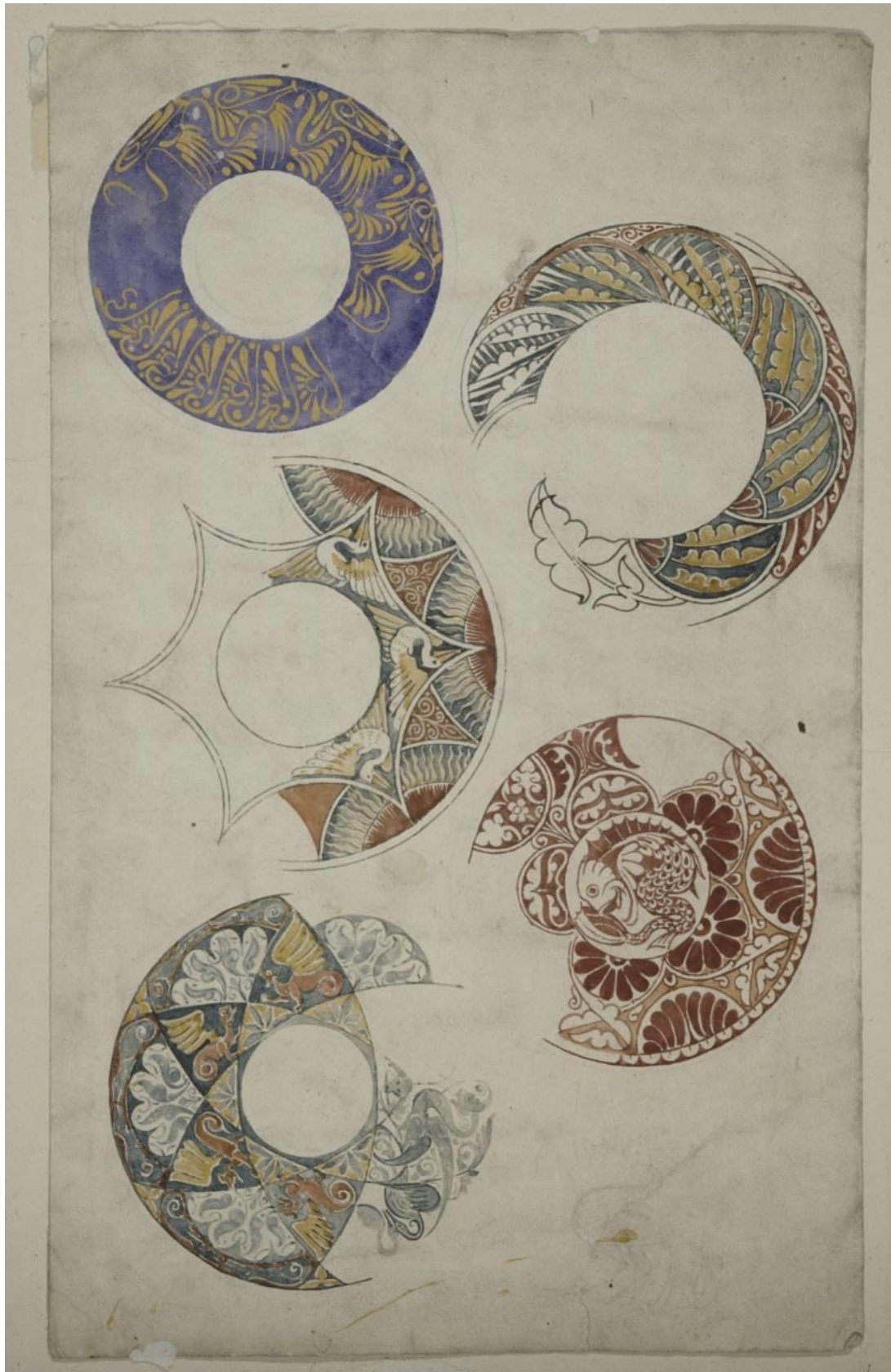
CIRCLES

Circles are shapes with only one side that goes on forever.

Look at these William De Morgan designs. Can you see how he has used arcs to create circular patterns?
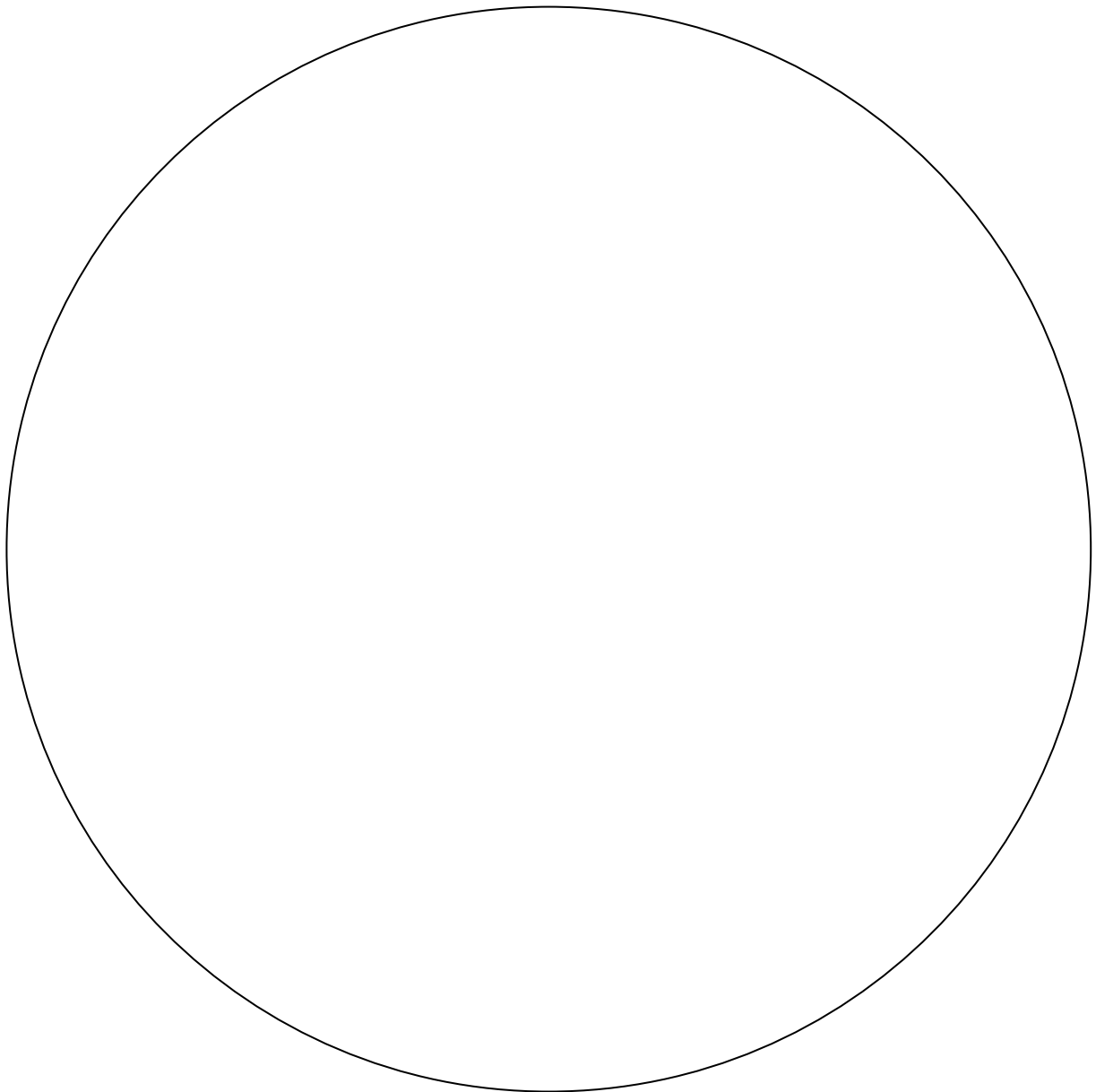
CIRCLES

Using compasses, try making your own plate design that is made up of arcs like William De Morgan's designs.

When you have finished, label any of the parts of a circle you can see in your design from the list below.
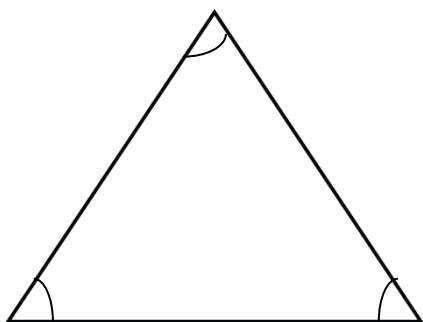
- Circumference
- Radius
- Diameter
- Tangent
- Arc
- Segment

WORKSHEET 10

TRIANGLES

> Triangles are polygons with three sides.
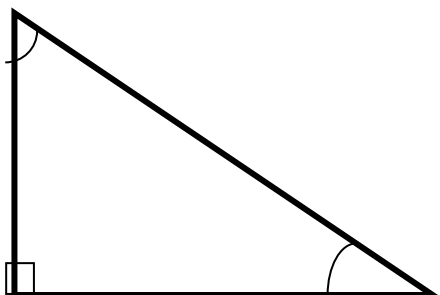> There are many different types of triangle.

1. **Equilateral triangle**

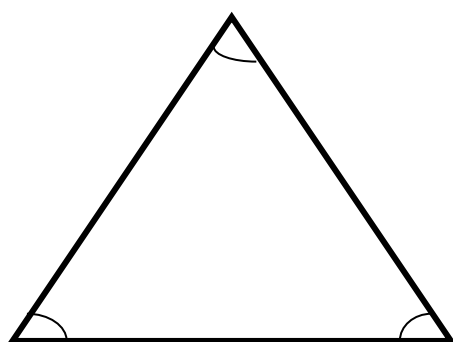An equilateral triangle has three equal sides.

Three equal angles which measure ....°

The total of the three angles is ....°

2. **Right-angle triangle**

One angle is a right angle. A right angle measures ....°

The three angles add up to ....°

3. **Isosceles triangle**

An isosceles triangle has .... equal sides and

.... equal angles.

The three angles add up to ....°

4. **Scalene triangle**
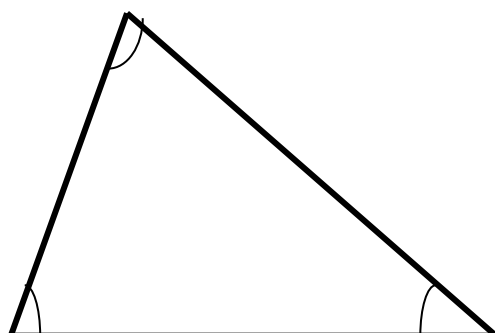
A scalene triangle has no equal sides or angles.

The three angles add up to ....°

The three angles in a triangle always add up to ....°

WORKSHEET 11

TRIANGLES

3

2

4

1

5

Find the triangles in this tile design. Measure the angles and sides of each and explain what type of triangle each is.

1. ....° ....° ....° ....cm ....cm ....cm

   Triangle 1 is a .... triangle

2. ....° ....° ....° ....cm ....cm ....cm

   Triangle 2 is a .... triangle

3. ....° ....° ....° ....cm ....cm ....cm

   Triangle 3 is a .... triangle

4. ....° ....° ....° ....cm ....cm ....cm

   Triangle 4 is a .... triangle

5. ....° ....° ....° ....cm ....cm ....cm

   Triangle 5 is a .... triangle

TRIANGLES

In this plate, William De Morgan has designed three beetles in triangles.

Join the yellow dots and the blue dots to reveal these triangles.

Measure the sides and angles of the triangles. What sort of triangle have you drawn?

HEXAGONS

If you look carefully, you will see that William De Morgan has used a hexagon to organise this design. Join the yellow dots to help you.
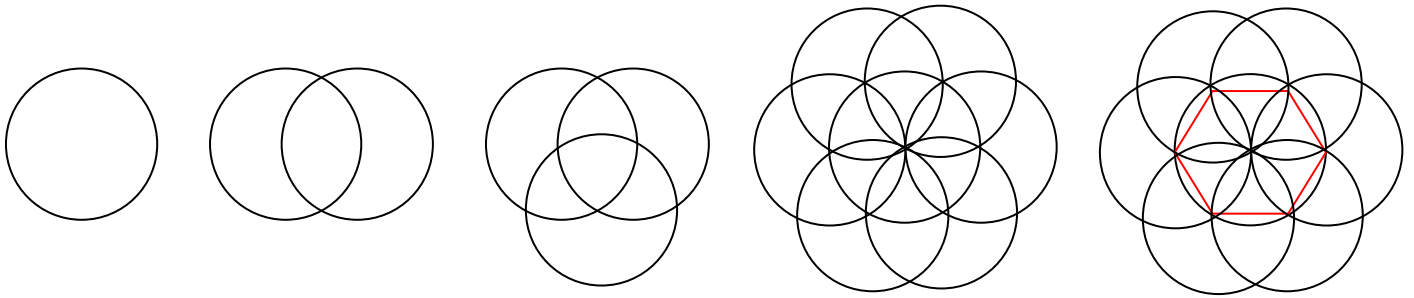

A regular polygon has sides of equal lengths and angles of equal sizes. Measure the sides and angles of the hexagon you have just drawn.
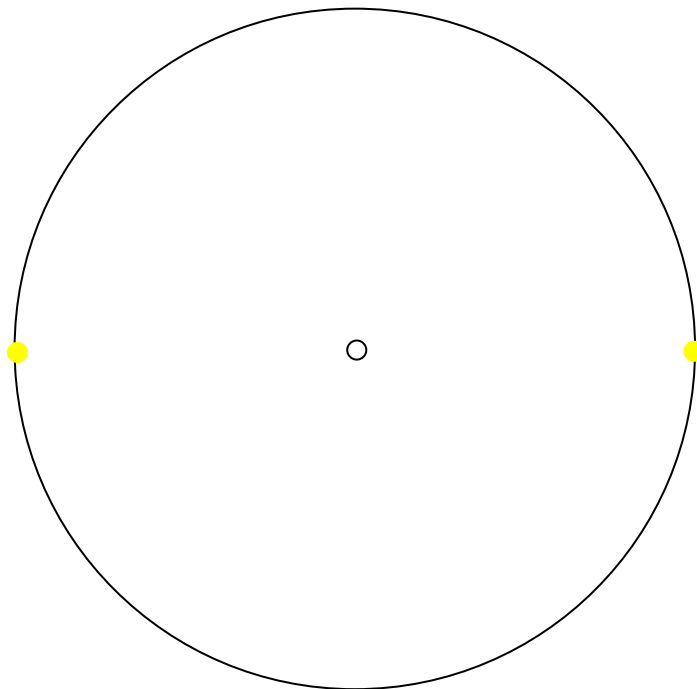
Is this a regular hexagon?

HEXAGONS

You can use circles to draw a regular hexagon. Keeping your compasses at 4.5cm, put your compass point on each yellow dot and draw two circles.

Then draw four more circles with a 4.5cm radius by placing the point of your compasses where the lines of the circles cross. Join the points of the flower shape to draw a hexagon.

HEXAGONS

Use your compasses to draw a hexagon in the space provided.

1. Set the length of your open compasses to 3cm.
2. Place the point on the X and draw a circle.
3. Place the point anywhere on the circle's circumference, and draw another circle. Keep your length at 3cm.
4. Draw a circle on all of the points where the circumferences of circles cross over, until you can see a flower shape with six petals.
5. Join the petal tips using a ruler.
6. Do you have a hexagon? Go over the outline of the hexagon in pen and then rub out your pencil markings.
7. Measure and label all of the sides and angles of your hexagon. Is it a regular polygon?

X

REFLECTIVE SYMMETRY

SUBLIME SYMMETRY

A shape or pattern has a line of symmetry if both halves are mirror images of each other. William De Morgan made lots of his designs with a line of symmetry.

Place a mirror on the line of symmetry to reflect the image.

Can you make each half look exactly like the whole design?

This tile panel by William De Morgan has a line of symmetry which has been drawn on it for you. Can you draw all of the lines of symmetry in the shapes below?
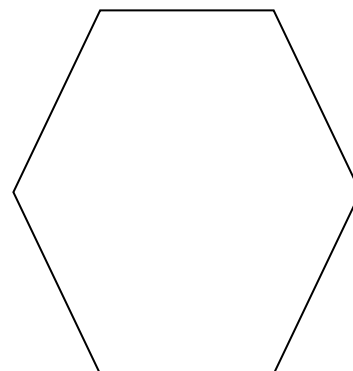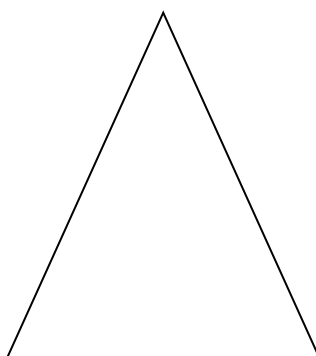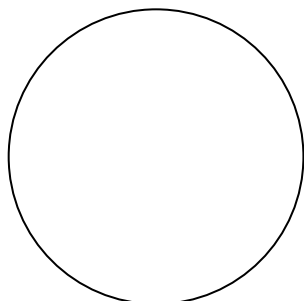
REFLECTIVE SYMMETRY

Trace over the outline of these William De Morgan tiles on tracing paper. Flip the paper over and stick it down to finish off the symmetrical design.
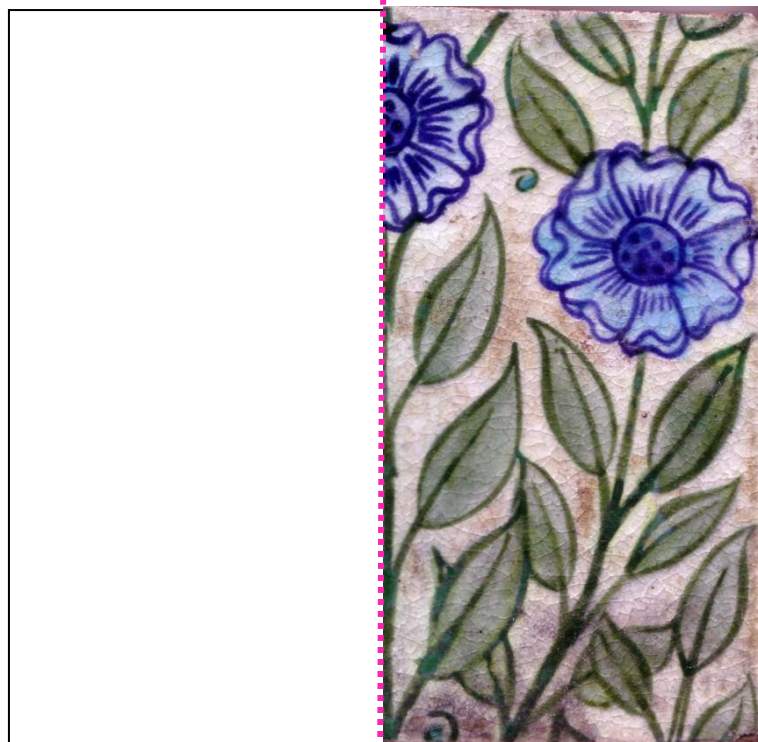
ROTATIONS

When a shape or pattern is repeated around a point, it has rotational symmetry.

How many times has the winged creature been rotated in this dish design?

1. Fix a sheet of tracing paper over William De Morgan's *Winged Feline Dish* by pushing a split pin through both sheets where X marks the spot.
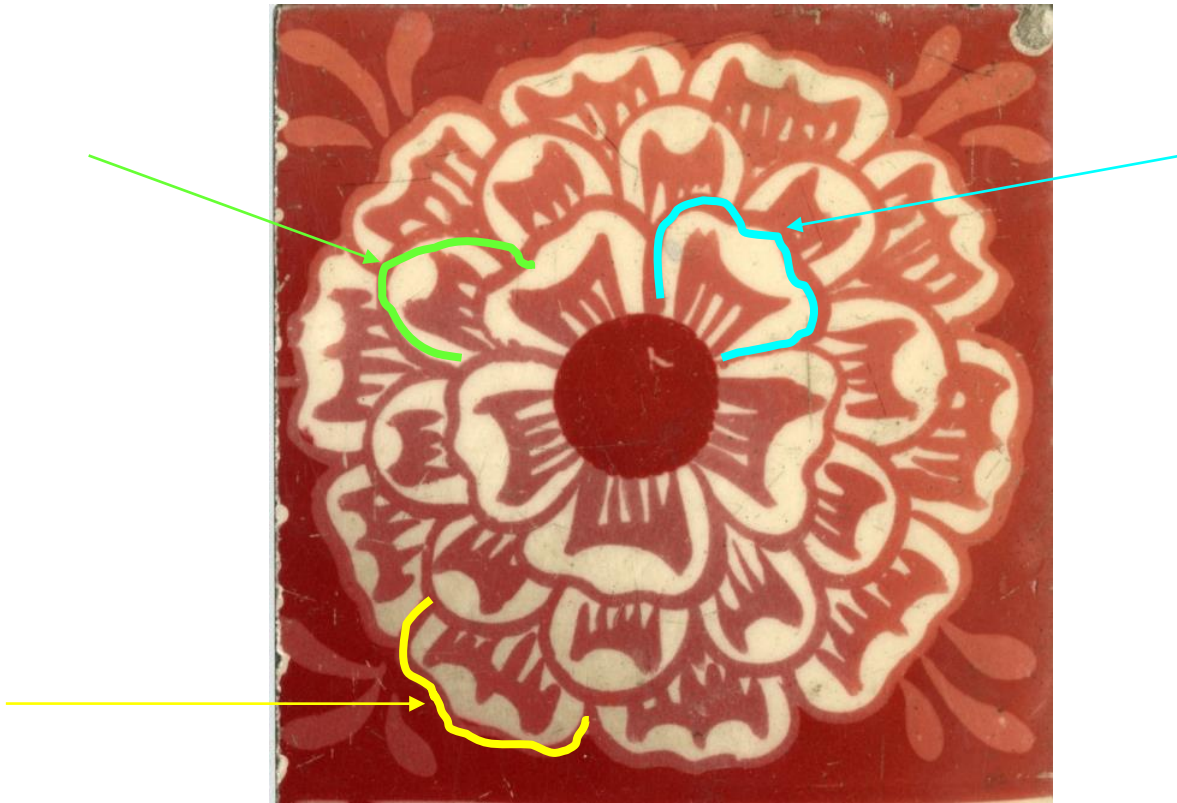2. Trace the top creature.
3. Rotate the tracing paper.

How many times has De Morgan rotated the creature in this design? ....
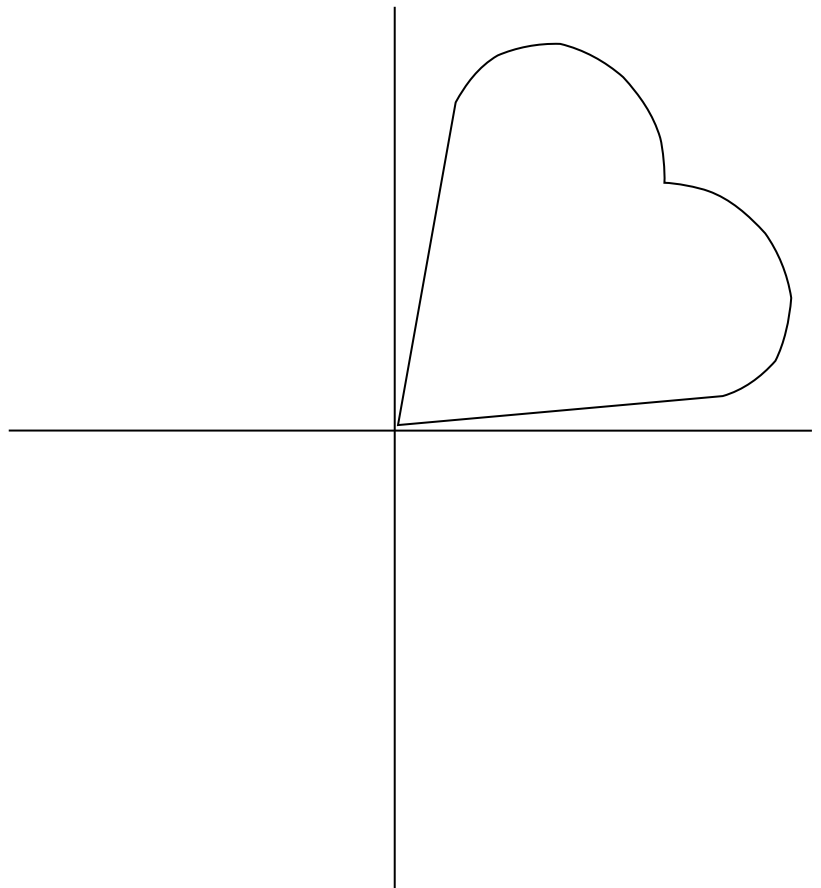
ROTATIONS

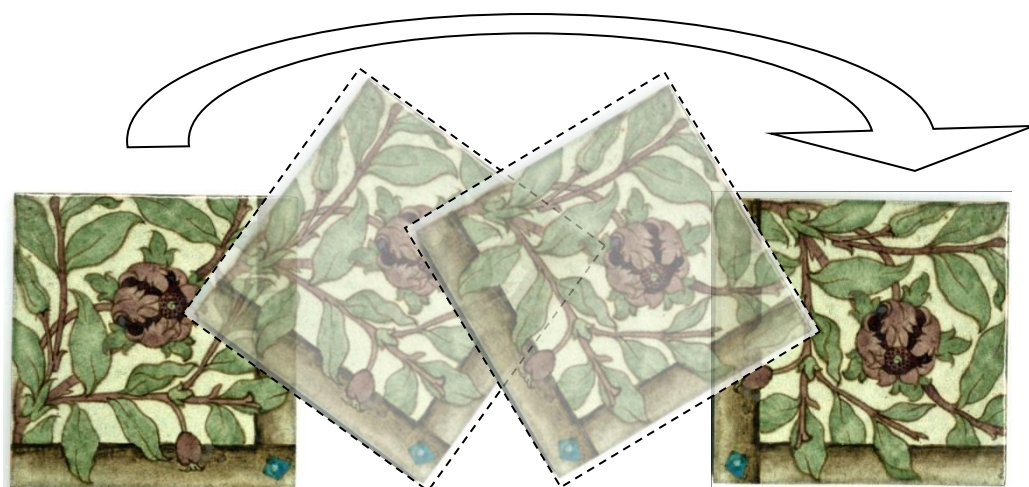How many times has each petal shape been rotated in this tile design?

Draw a flower with rotational symmetry by rotating this petal and drawing it again in the spaces.

How many rotations of the same shape are there?

SUBLIME SYMMETRY

ROTATIONS

William De Morgan's *Rose and Trellis* tile design can be rotated to create a tile pattern.

The tile has been rotated one quarter turn.

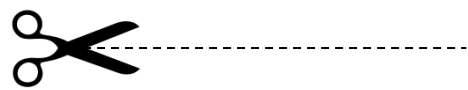There are four quarter turns in one full turn.

You can measure the angle of a quarter turn. Measure the angle below.

...........°

As the tile rotates, it travels *through* the angle you have measured. We say that the shape has been rotated

one .... turn through ....°

Cut out the tiles below.

Make your own rotating *Rose and Trellis* design.

1. Stick your first tile in position 1.

2. Place your second tile on top of tile 1 and then rotate it one quarter turn through 90° into space 2 and stick it down.

3. Place your third tile on top of tile 2 and rotate it one quarter turn through 90° into space 3 and stick it down.

4. Place your fourth tile on top of tile 3 and rotate it one quarter turn through 90° into space 2 and stick it down.

1

2

4

3