

# St Paul's Cathedral maths trail



## UNIT A5

This unit provides a ready-made maths trail around St Paul's Cathedral. The ideas can be adapted for use in different churches or cathedrals or indeed for any interesting large building.

### Using the unit

Entry to St. Paul's is free for British school parties but times should be booked in advance (tel no 020 7246 8319) to ensure that all areas are accessible for the trail. There is a small charge per head to go up into the galleries. The maths trail does not involve the galleries but a visit to the roof provides an interesting extra activity. There are refreshment and toilet facilities in the crypt and a gift shop. The trail is entirely inside the cathedral and crypt.

Pupils should work in small groups. The trail covers four separate areas in the main cathedral. Groups can start at any one of the areas to avoid congestion. They are likely to spend 15 to 20 minutes at each site and will probably take a further 5 minutes finding the next one so the work in the main cathedral will probably take about 1½ hours. There are also two sections for use in the crypt. These could be tackled simultaneously if staffing allows or they could form a second session taking a total time of about 1 hour, say after lunch.

During the visit, there is plenty to discuss both mathematically and spiritually. Maximum benefit will come from encouraging the pupils to have in mind throughout the trail, the question of why the designs are as they are. They should keep asking themselves what inspired people to create such a building, every detail of its design and the contents in the way that they have. Possible answers might include: to make a special building for God, to make a great building worthy of a great God, to show off their skills, to design the very best that they could design as a gift to God, to design the biggest and best building in England etc.

### Preparation for the visit and follow up

It would be advisable to introduce or revise Roman numerals, geometric shapes and tessellations before going to St.Paul's. Answers can be checked in class on your return. There are no answers given to the sections in the trail which indicate that the pupils should "think about" something. These can be followed up in class discussion. Pupils can be encouraged to reflect upon, write up or discuss their responses to visiting the cathedral. A class display could be produced about the cathedral and about what pupils have learned.

### Before you go inside the cathedral

It would be good to ask pupils to pause to look at the outside of building; the steps, the dome, the roof etc. A walk around the outside of the cathedral would help them to appreciate its size. Encourage them to reflect on the size, scale, shape, design and magnificence of its structure and to consider why Sir Christopher Wren might have designed and built it like this.

### Differentiation

The unit contains material suitable for pupils of a wide range of ability levels. Where appropriate, some questions can be identified beforehand as being optional for pupils or to be omitted.

### Mathematical content

Shape, space and measure (AT3)

- ◆ Classifying 3-D and 2-D shapes in various ways using mathematical properties such as line symmetry (level 3)

- ◆ Identifying all the symmetries of 2-D shapes (level 5)

(The final section contains some simple calculations and the use of Roman numerals.)

### Spiritual and moral development

The aim is to provide opportunity for pupils to reflect upon the purpose of a building such as St. Paul's Cathedral and to appreciate the spiritual significance of its architecture and the works of art that it contains.

### Resources needed

Each pupil needs a copy of the maths trail, a pen or pencil and a clipboard or something similar to support the worksheets while writing on them.

**Adaptations**

The idea of a trail can be adapted to other cathedrals or churches or indeed any large and architecturally interesting building. Your choice of building will affect the potential for spiritual development. We suggest that you visit the building beforehand and list the mathematical features that you want to use. It is easier if you look under particular headings, e.g. line symmetry, rotational symmetry, geometric shapes, transformations, tessellations, measurement, etc. Write the questions, dividing the building into separate areas to avoid congestion and then return to the building on another occasion to check accuracy, timing and answers. It is most helpful to have a second person to trial your questions before taking the pupils.

**Answers****A The Nave**

1. Square and rectangle.
2. 18 squares, 15 rectangles.
3. 2
4. Yes, order 2.
5. 4 on either side, 8 in all.
6. Sketch
7. Rectangle and semicircle.
8. Circle
9. 3

**B North Aisle**

1. Hexagon
2. Octagon
3. Hexagon
4. Sketch
5. 3 (looks like 6 at first glance)
6. Square
7. 4
8. Divide  $360^\circ$  by the number of shapes meeting at the point (i.e. 4, giving  $90^\circ$ ).
9. Kite or rhombus or parallelogram.

**C Under the Dome**

1. 8 (allow 16 as each is really a double pillar); to spread the load.
2. Sir Christopher Wren designed this with a compass in mind. Other possibilities: a star, a sunburst.
3. a) 8  
b) Yes, 8.
4. Kite
5. Triangle and kite.
6. Kite
7. Octagon with a semicircle cut out of it.
8. a) For example, high up, elaborate carvings, canopy, etc.

- b) For example, it is used for teaching from the Bible, for speaking to the gathered people.

**D The American Memorial Chapel and North Transept**

1. Pentagon
2. Isosceles
3. Both are kites although at first glance the outer one appears to be a rhombus.
4. Strictly, a helix (but accept a spiral).
5. 1st on right as you face the panels.
6. Cylinder
7. For discussion.
8. Rectangle and Trapezium.
9. Ellipse (oval)
10. No line symmetry but rotational symmetry of order 3.

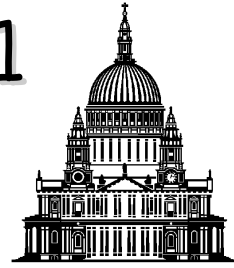
**E The Crypt, Tombs and Numerals**

1. 74
2. 89
3. 8
4. a) 90  
b) 2010
5. a) MDCCLXIX=1769  
b) MDCCCLII=1852  
c) 83
6. a) MDCCXXIII=1723  
b) XCI=91  
c) 1632

**F The Crypt, Models and Mosaics**

1. Any 8 of: parallelogram, circle, rhombus, octagon, square, triangle, rectangle, trapezium, kite, semicircle, concave decagon, sector of circle.
2. a) 4  
b) Sketch  
c) and d) should be consistent with the sketch.
3. a) Sketch  
b) Should be consistent with the sketch.
4. Equilateral
5. Father, Son and Spirit - the Trinity. The words and design indicate that Christians believe that God is three distinct persons: God the Father, Jesus the Son and the Holy Spirit, yet they are also one God.
6. These answers are from the models, not the actual building.
  - a) Old St. Paul's
  - b) 150 feet
  - c)  $520 - 150 = 370$  feet
7. The spire and the dome.
8. a) Both in the form of a cross.  
b) The cross is the symbol of the Christian faith.

# St Paul's Cathedral maths trail



## UNIT A5

► Before you start, take time to read this introduction.

### Where am I?

You are standing inside a cathedral. A cathedral is a large building in which Christians get together to worship God. It is the central church for a large area.

You will notice that it is very quiet in the cathedral. That is because people may be talking to God in prayer. When you are talking to someone, you expect people not to interrupt you. In the same way, please don't disturb other people by making a lot of noise.

Every hour, everything in the cathedral stops while someone comes to lead the praying. You will also be asked to stop what you are doing as a mark of respect.



### When was it built?

The cathedral you are standing in now has been here for about 300 years. Several Saxon churches had been built on this site. The first of these was built in the year 604.

The cathedral previous to the present day St Paul's had a spire. In 1561 it was struck by lightning and collapsed. A hundred years later, the king, Charles II, asked Sir Christopher Wren to design something to replace the spire, but before work could begin, the old cathedral burned down! In the autumn of 1666, the Great Fire swept through London destroying every wooden building it came to, including St Paul's Cathedral, 87 other churches and about 13,200 houses. So Sir Christopher Wren had the opportunity to build a completely new cathedral of stone.

The building work began in 1675 and was eventually finished in 1710. Wren had to battle with the cathedral authorities over the design: he wanted to build a cathedral with a dome, and the cathedral authorities wanted it to have a spire. If you look at the building, you can see who won!

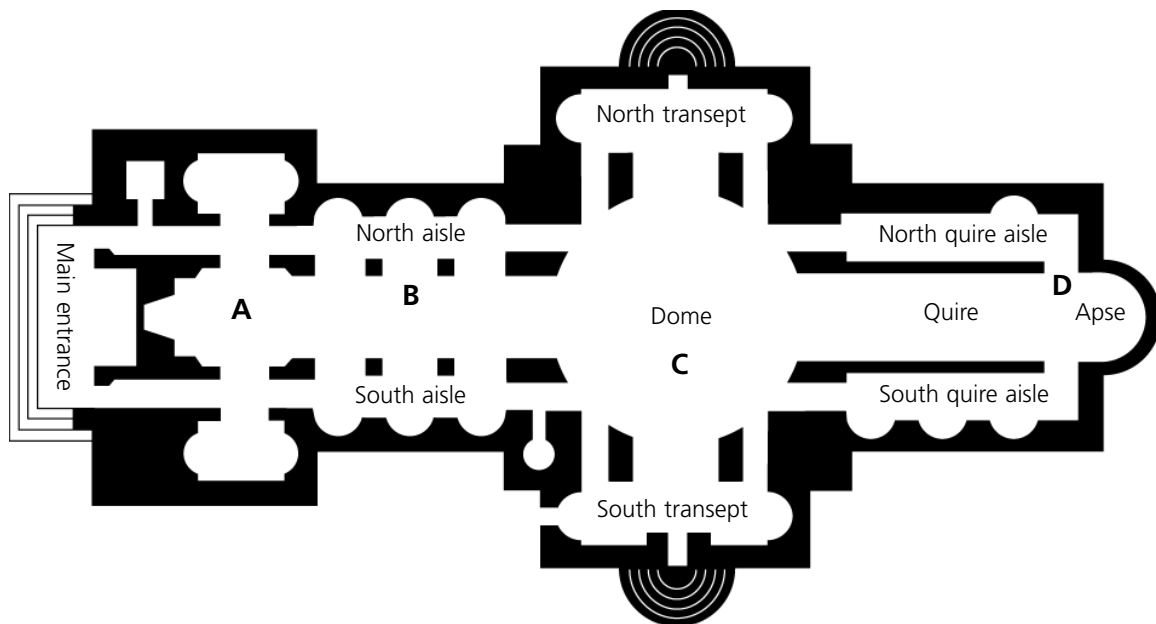
### How big is it?

- The cathedral is 157 metres long and 76 metres wide.
- The very highest point on the cathedral is 111.3 metres from the ground (111.3 metres = 365 feet, one for each day of the year). As you can probably guess, this is at the top of the dome. If you look at the plan of the cathedral on the next page, you will see that the whole building is in the shape of a cross and that the dome is positioned where the two sections meet in the middle.
- The dome weighs 65,000 tonnes (that is 65 million bags of sugar!) and it is supported by eight pillars.
- The organ in St Paul's is the third largest in the UK and has 7,189 pipes. (If you run out of things to do, perhaps you could check to make sure they didn't miss any when they were counting!)



**Glossary - some of the main parts of the cathedral.**

- **CRYPT:** this runs under the cathedral from one end all the way to the other, and is where some people are buried, like an indoor graveyard. There are some famous people buried here, e.g. Sir Christopher Wren (who designed the cathedral), Sir Joshua Reynolds (a painter), Sir Alexander Fleming (a scientist, who discovered penicillin) and Sir Arthur Sullivan (a composer).
- **FONT:** this is located in the North Transept. Water placed in the font is used to make the sign of the cross on the foreheads of people when they are welcomed as members of the Christian church.
- **HIGH ALTAR:** this is located in the Quire. It is made of marble and gold covered carved oak. It is a memorial to all those who died in the two World Wars.
- **NAVE:** the long central section leading to the dome.
- **PULPIT:** this is located under the dome. From here, the church leaders teach from the Bible. It is raised up so that everybody can see and hear the speaker.
- **QUIRE** (pronounced choir): the shorter section on the other side of the dome from the Nave. This is where the choir and the priests (the church leaders) normally sit during services and where the **ORGAN** is found.



The areas marked A, B, C and D on the plan refer to worksheets A, B, C and D. Worksheets E and F are for the Crypt.

- When you enter the cathedral, pause for a few minutes before starting your maths trail. Be quiet and look all around you. Look at the ceiling, the walls, the floor, up and down the length of the cathedral.

Think of words to describe the cathedral. What do you think Sir Christopher Wren wanted you to think about when you came into this cathedral?

# A

## The Nave: Geometric shapes and symmetry

**Look at the huge west doors of the cathedral. There is a pattern carved on them. Answer these questions for one of the doors only.**

1. There are two quadrilaterals (4-sided shapes) in the pattern on the door. What are they called?

**Answer:**

2. How many of each of these quadrilaterals are there on one door?

**Answer:**

3. How many lines of symmetry does the pattern on one door have?

**Answer:**

4. Does the pattern on one door have rotational symmetry? If so, what is the order?

**Answer:**



**Look at the huge stone arches on either side of you.**

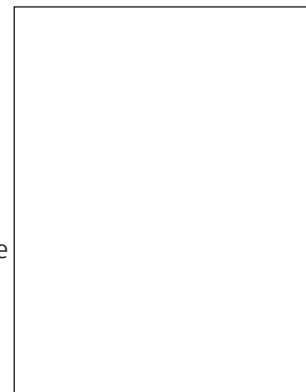
5. How many archways lead off the nave to either side?

**Answer:**

6. Look through one of the arches nearest the back of the cathedral, i.e. nearest to the main door. In the space given, sketch the shape of the window.

7. Which two mathematical shapes go together to make up the shape you have drawn?

**Answer:**



**Look at the ceiling above the nave.**

8. Which is the main shape repeated across the ceiling?

**Answer:**

9. Not all these shapes are the same size. How many different sizes of this shape are there in the ceiling of the nave, i.e. above the central aisle?

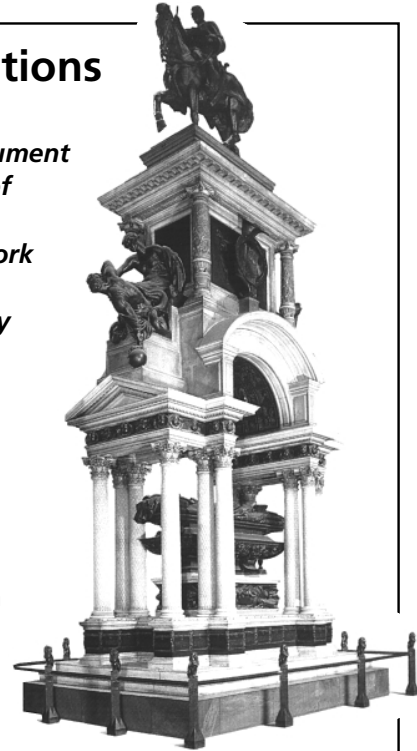
**Answer:**

# B

## North Aisle: Patterns and tessellations

**Stand near Wellington's monument. This is the large monument with the horse on the top. It is a monument to the Duke of Wellington, commemorating his life and his victory at the Battle of Waterloo. Look up at the patterns in the stonework over the windows. Each window arch has a different tessellating pattern: i.e. one that can be repeated endlessly over a large area.**

1. Which mathematical shape makes up the pattern over the window directly opposite Wellington's monument?  
**Answer:**
2. Which shape makes up the pattern over the window to your right (i.e. nearest to the altar)? **Answer:**
3. Only one of the shapes in questions 1 and 2 can tessellate on its own. Which one is it? **Answer:**
4. The window to your left (i.e. towards the door) has a more complicated pattern. Sketch the basic pattern in the box.



**Look at the floor near the monument. You should see a brass grille set into the floor.**

5. Examine the pattern cut out of the grille. It has rotational symmetry. What is the order?

**Answer:**

**Look at the rest of the floor where there is a tessellating pattern.**

6. Which basic shape makes up this tessellation?  
**Answer:**
7. Look at one vertex (corner) of this basic shape. How many of these shapes meet at this point?

**Answer:**

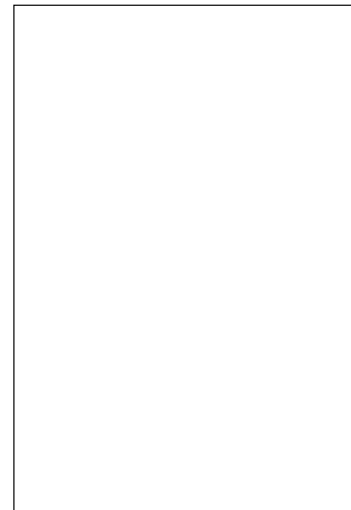
8. Explain how you can use your answer to question 7 to help you to find the size of the angle between two sides of the basic shape.

**Answer:**

**Look at the pillars supporting the roof of Wellington's monument. The pattern on the pillars is also a tessellation with a leaf design.**

9. Which mathematical shape most resembles the shape of the leaf?

**Answer:**





## Under the Dome: Three dimensional drama

*This is the most dramatic part of the cathedral. Stand in the very centre of the space under the dome and think about the way Sir Christopher Wren, the architect, has used the space around you. Look up at the very centre of the dome above your head and you can see a tiny window. If you climb up the stairs to the top of the dome you can look down through this window to the exact spot where you are standing now.*

1. How many separate pillars support the dome?  
Why do you think Wren chose to use so many?

**Answer:**

Think about the amazing mathematical precision needed in constructing this huge building without using modern instruments. Take time to reflect on the scale and magnificence of this part of the cathedral.

- It might make us think about the skill of Sir Christopher Wren and his builders.
- It might make us think about God because of this enormous building.

What do you think Sir Christopher Wren would have wanted us to think?

*Look at the pattern on the floor under the dome.*

2. What object do you think the central starred pattern is meant to suggest?

**Answer:**

3. In the centre of the starred pattern is a brass grille.

- a) What is the order of rotational symmetry of the pattern cut out of the grille?

**Answer:**

- b) Does the pattern have any lines of symmetry, and if so, how many?

**Answer:**

4. Outside the brass grille, but inside the circle of writing you can see a circle of mathematical shapes. What shape is this?

**Answer:**

***The circle of writing is in Latin and if it is translated into English it reads:***

***"Beneath lies buried the founder of this church and city Christopher Wren, who lived more than ninety years not for himself but for the public good. Reader, if you seek his monument, look around you."***

5. Outside the circle of writing there is a large circle containing shapes in grey and brown. Name the two different mathematical shapes that make up the grey and brown pattern.

**Answer:**

6. Around the outside of the grey and brown pattern are two black circles. Between these two circles is another mathematical shape in black. What is the name of the shape?  
(Check its angles and the lengths of its sides carefully before you answer.)

**Answer:**

***Finally look at the pulpit. It was installed fairly recently on the cathedral's 250th birthday. Every hour prayers are read from the pulpit to remind visitors that the cathedral exists to help us worship God.***

7. The canopy (umbrella-like roof) over the pulpit is based on a polygon with another shape cut out of the front of it. Name the polygon and the cut out shape.

**Answer:**

8. a) The person who designed the pulpit wanted to make it an important feature of the cathedral. Can you list three things that you think make it look important?

**Answer:**

- b) Why do you think he wanted to make it important?

**Answer:**



## D

## The American Memorial Chapel and North Transept: Stars and symbols

*This end of the cathedral was badly damaged in the war and was rebuilt in the 1950s as a memorial chapel for 28,000 Americans who were stationed in Britain and died in the war. Look at one of the patterns on the floor on either side of the chapel. You should see a star pattern set in a circle.*

1. Name the mathematical shape at the centre of this pattern.

**Answer:**

2. What sort of triangle makes up one point of the star?

**Answer:**

3. Look at the main pattern in the centre of the chapel floor. There are two black quadrilaterals inside the circular arcs. What sort of quadrilateral are they? Check carefully before you answer.

**Answer:**

*There are some unusual wooden pillars in this area. They have a pattern of gold leaves climbing up them.*

4. How would you describe the shape of these pillars?

**Answer:**

*Look carefully at the carved wooden panels on the wall of the chapel. The 8 strips of carving in between the panels are of American birds, plants and flowers. There is even a space rocket hidden in one of the panels.*

5. Which panel contains the space rocket? Make your answer clear. (For example, 'the third panel' is not clear whereas 'the third panel from the left' is clear.)

**Answer:**

These Americans died fighting for freedom in Europe. Why do you think there is a memorial in the cathedral?

Think about these words of Jesus found in the Bible: "Love each other as I have loved you. Greater love has no-one than this, that he lay down his life for his friends." (John chapter 15, verses 12 - 13) Can you think of anything that people today are prepared to die for?

**Now move towards the north side of the cathedral behind the choir stalls (where the choir sits). There you will find a sculpture by Henry Moore called 'Mother and Child'.**

6. Look at the solid which forms the base for the sculpture. What is its mathematical name?

**Answer:**

**Henry Moore chose to place this sculpture in the cathedral.**

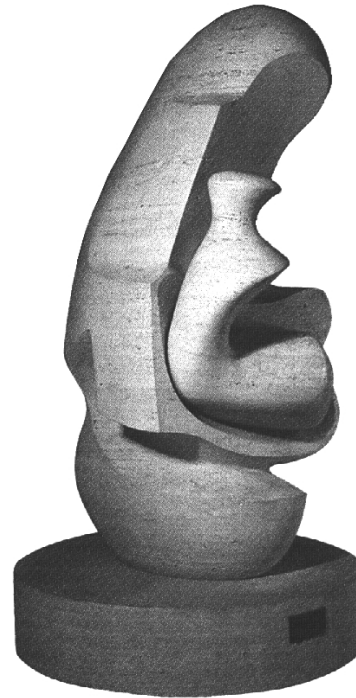
7. Why do you think he might have done this?

**Answer:**

**Walk down the choir aisle and look at the last door on your left marked 'ORGANISTA'.**

8. There is an iron grille in this door. In the centre of the grille are two different quadrilaterals. What are their names?

**Answer:**



**Move into the North Transept where you will see a large marble font where water is placed for baptisms.**

9. The font is an unusual shape. If you looked at the font from above, what two dimensional shape would you see?

**Answer:**

10. Look at the glass panels surrounding the font. Each one has a fish design on it.

- a) Does the design have any lines of symmetry? If so, how many?

**Answer:**

- b) Does it have rotational symmetry? If so, what is the order?

**Answer:**

Now look on the wall at the cathedral's most famous painting by Holman Hunt. What do you think the artist was trying to say in this picture? Read the Bible verse under the picture for a clue.



## The Crypt: Tombs and numerals

**Many people, famous and not so famous are buried here in the crypt. You are going to find out something about them and how old they were when they died. Start in the crypt chapel.**

1. On the wall of the chapel you will find a plaque to mark the burial place of Alexander Fleming, the famous chemist who discovered penicillin. How old was Fleming when he died?

**Answer:**

2. Outside the chapel you will find a plaque on the wall commemorating the life of Viscount Montgomery of Alamein, known as 'Monty'. He was a famous commander in the second world war. How old was he when he died?

**Answer:**

3. Nearby you will find Nelson's tomb. How many pillars surround the tomb?

**Answer:**

**Before you leave Nelson's tomb, read the prayer that he prayed before the Battle of Trafalgar on 21st October 1805.**

4. Nearby you will find the memorial plaque to Florence Nightingale who helped found the modern nursing profession.

- a) How old was Florence Nightingale when she died?

**Answer:**

- b) We shall soon be celebrating the centenary (100 years) of her death. In which year will we celebrate it?

**Answer:**

**1**

For the rest of the questions you will need to understand Roman numerals. Here is a key:

I = 1; II = 2; III = 3; IV = 4; V = 5;  
VI = 6; VII = 7; VIII = 8; IX = 9; and  
X = 10.  
L = 50; C = 100; D = 500; and  
M = 1000.

Notice that a smaller number placed in front of a larger one is subtracted, so IV means 4 and IX means 9. In the same way XC means 90. Give all your answers in ordinary numbers.

5. Find Wellington's tomb.

- a) In which year was he born?

**Answer:**

- b) In which year did he die?

**Answer:**

- c) How old was he when he died?

**Answer:**

6. Go back to the chapel and find Sir Christopher Wren's Tomb.

- a) In which year did Wren die?

**Answer:**

- b) How old was he when he died?

**Answer:**

- c) In which year was Wren born? Give your answer in ordinary numbers.

**Answer:**

Think back to the Henry Moore sculpture, "Mother and Child", that you saw in the North Quire Aisle. This statue of the Madonna and Child in the crypt chapel represents Jesus and his mother Mary. Do you think Henry Moore's sculpture was of a special mother and child or any mother and child? Which of the 2 statues do you like best? Can you say why?

**Before you leave the crypt chapel look for the statue of the Madonna and Child. The sculptress has hidden a tiny mouse in the sculpture. Can you find it?**



## The Crypt: Models and mosaics

*The crypt has many interesting mosaic patterns on the floor.*

1. Find Nelson's tomb and look at the mosaic patterns on the floor around the tomb. List 8 mathematical shapes that you can see in the patterns.

**Answer:**

*Find Florence Nightingale's memorial plaque. Look at the mosaic floor here. There are 12 large circles on the floor. Each one contains a pattern.*

2. a) How many different patterns are there? **Answer:**  
 b) In the box, sketch one of the patterns which has both line and rotational symmetry.  
 c) How many lines of symmetry does your sketch have?

**Answer:**

- d) What is the order of rotational symmetry of your sketch?

**Answer:**

3. a) In the box, sketch one of the patterns from the floor which has only rotational symmetry.  
 b) What is the order of rotational symmetry of your sketch?

**Answer:**

*Find the square of peacocks on the floor just beyond Florence Nightingale's plaque.*

4. What sort of triangle is at the centre of this square? **Answer:**  
 5. What do the three corners of the triangle represent? There is a clue in the Latin writing. From the words, can you explain what this symbol means?

**Answer:**

*The crypt also contains two models, one of the old St. Paul's which was burned down in the Great Fire of London in 1666, and one of the present building. Have a look at the two models and then answer these questions.*

6. a) Which building was the taller of the two? **Answer:**  
 b) What is the difference in the two heights? Give your answer in feet. **Answer:**  
 c) From the information given on the models, calculate the height of the present building in feet. **Answer:**
7. What do you think is the main difference in the two designs?

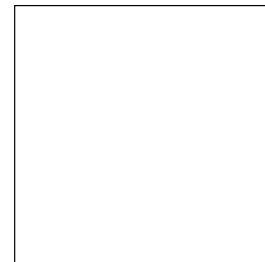
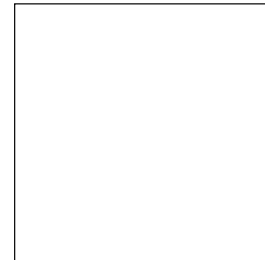
**Answer:**

8. a) Look at the shape of the floor on the two models. What is similar about the shapes?

**Answer:**

- b) Why do you think this is?

**Answer:**



DEUS	God
EST	is
FILIUS	Son
NON	not
PATER	Father
SPIRITUS	Spirit