SCIENCE MUSEUM

WONDERLAB: THE EQUINOR GALLERY

The science and maths behind the exhibits

INFORMATION	Age	Topic	
	7–11 11–14	MATHS	30 MIN
	Location	LEVEL 3, SCIENCE MUSEUM, LONDON	

What's the maths?

What more will you wonder?
The maths behind the exhibits

Wonderlab: The Equinor Gallery is packed with over 50 hands-on experiments and experiences. You need to look closer, ask questions and get creative to discover what they're all about.

If you're still curious you can find out more about the science and maths behind each of the exhibits using these handy resource packs. Check out each of the seven zones that you'll find in the gallery.

Maths

Whether it's patterns or problems, so much of the world can be explained by maths. You can use logic to solve many of these problems. Our lives are filled with maths and we hardly ever know it.

Find out more about the maths behind the Maths zone exhibits in this pack.

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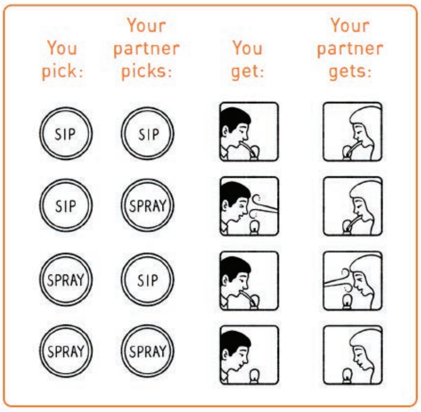
The maths behind the exhibit



Sip or Spray is no ordinary drinking fountain. Depending on the choices both you and your partner make there are different outcomes.

Your best strategy will depend on what you want to happen. If you want a sip of water and don't want to get sprayed in the face, then your best strategy is actually to press spray. This is because pressing spray means there is no chance that you could get sprayed in the face (see the diagram left). But there is a 50% chance you could get the water you want. However, if you choose sip, there is still only a 50% chance you can get the water you want, but there is also a 50% chance you could get sprayed in the face. So the safest strategy here is to press spray, even though it seems the wrong way round.

On the other hand, if you want to get sprayed in the face your best strategy is to press sip! Again, a bit strange – but look at the diagram. If you press sip there's a 50% chance you can get sprayed in the face, but if you press spray there's actually no chance you can get sprayed.

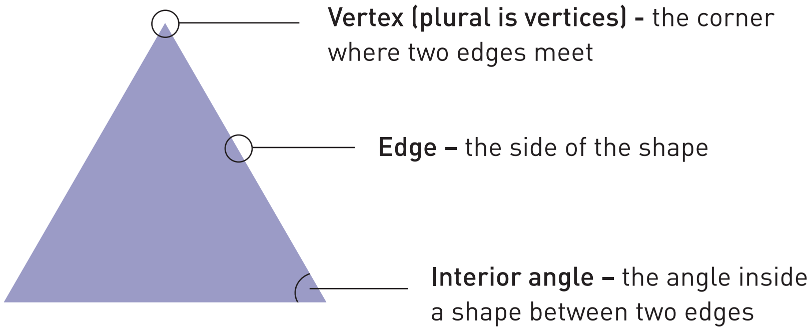
This game is all about logical decision-making. This is a similar problem to the 'prisoner's dilemma', a famous example of game theory. This is an area of maths that studies rational decision-making to help us make better decisions or be able to predict the outcome of events. Often game theory simplifies behaviour and assumes people will always act rationally in their own self-interest. So it doesn't always represent reality, but it does help us develop strategies to solve problems.

For example, if you want to share a cake between two people, game theory can help find a way to share it so that you both get what you want. Game theory says the best way to share a cake is for one person to slice it and the other person to choose a piece first. That way if they both want half the cake the incentive for the slicer is to make the two halves as even as possible, or they might lose out when the picker takes the larger slice.

The maths behind the exhibit

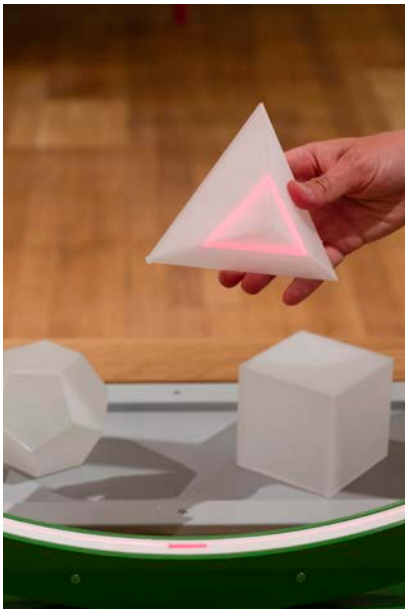
Tessellation Wall is all about making patterns with shapes. To tessellate you need to place the shapes together on a flat surface so that they have no gaps or overlaps. Many different kinds of shapes can be used in tessellation, but not all shapes tessellate well together.

Shapes can have the following components:



Shapes can be positioned together so that their edges and/or vertices meet. For example, squares tessellate. This can be seen by bringing the vertices of four squares to meet at a single point. The interior angle of each corner of a square is 90 degrees, so with four squares this equals 360 degrees. If shapes can be fitted together such that the internal angles around each vertex add up to 360 degrees then the shapes are said to tessellate. This means some irregular shapes can tessellate too. Sometimes to get shapes to tessellate the tiles need to be rotated, flipped or slid into place to line up together.

The maths behind the exhibit



Laser Slice lets you see the cross sections of solid, translucent 3D objects by placing them inside the laser ring. Any 3D shape has the three dimensions of height, width and depth.

There are many different kinds of 3D shapes, including cubes, cones, cylinders, spheres, pyramids and prisms. When these are cut they reveal a cross section, which is a 2D shape. For example, a slice of bread is a cross section of a loaf of bread that is cut vertically.

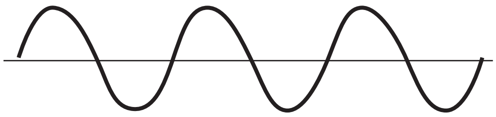
A 3D shape can also be sliced at an angle, which can create 2D cross sections that are not the same as any of the solid's faces. Diagonal cross sections will always make a 2D shape that has the same number of edges as the number of faces the slice cuts through. If we slice a cube at a corner so that it cuts the corner off, the slice goes through three faces of the cube and will create a triangle cross section.

The more faces we slice through in one go, the more edges the cross section will have. Therefore, in theory, the maximum number of edges that a cross section can have is equal to the number of faces of the solid. So for a cube we could slice it to make a cross-section shape with up to six sides. A cube can be sliced to give cross sections that are squares, rectangles, trapezoids, triangles, pentagons and hexagons. For many other solids though it can be quite difficult to slice through every face.

In this exhibit the laser highlights the slice through the object and shows you the cross-section shape inside the object.

The maths behind the exhibit

Pendulum Patterns is a great way to make spiral shapes and patterns using two pendulums. A pendulum is a weight that will swing freely back and forth. If a pen is attached to one swinging pendulum and a piece of paper is held beneath it, the pendulum will trace an ever-decreasing line on the paper while it swings. If you move the paper as the pendulum swings, this line will trace out a curve, called a sine wave. Depending on how the pendulum moves, the sine wave can vary in both height and how close together the peaks and troughs are.



Sine wave

If you look closely at the exhibit, you'll notice that it has two pendulums. One is connected to the pen and the other is underneath the table and connected to the clipboard holding the paper. These two pendulums swing in different directions to each other. This means the two sine waves that the pendulums trace out will be combined together to form a new pattern. When the pen is lowered onto the paper this pattern is drawn onto it.

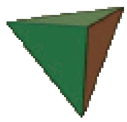
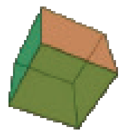
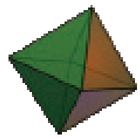
The pendulums slow down over time because of friction. As they do this they move in and out of sync with each other, making beautiful, intricate patterns to be drawn onto the paper. An incredible variety of patterns can be made because of the different ways the two pendulums can be swinging in relation to each other.

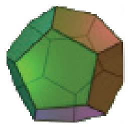
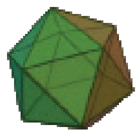
The maths behind the exhibit

Shapes such as triangles, squares, pentagons, hexagons and octagons have two dimensions of height and width. These shapes can be connected together in different combinations to make 3D objects. These 3D shapes have the three dimensions of height, width and depth.

You can make a 3D shape using only one kind of regular 2D shape, such as a triangle or square. If you ensure that the same number of shapes meet at each corner, and that the corners point outwards, then there are only five different 3D shapes like this you can make. These are called the Platonic solids.

They are:

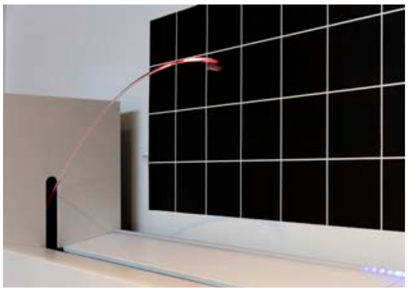
		
TETRAHEDRON	CUBE	OCTAHEDRON
4 triangles	6 squares	8 triangles

	
DODECAHEDRON	ICOSAHEDRON
12 pentagons	20 triangles

You can also build 3D objects using more than one kind of shape. If you start including different 2D shapes in the construction you can build many, many more varieties of 3D objects. Architects and engineers create innovative new building designs by creating 3D structures from 2D shapes. For instance the unusual shape of the 'Gherkin' building in London is made almost entirely from flat shapes combined together. There's only one curved piece of glass, on the very top.

Most 3D shapes can be constructed using nets. A net is what a 3D shape would look like if it were opened out flat. These nets can be folded up into a 3D shape. There may be several possible nets for one 3D shape. Opening up 3D objects in different ways can show the variety of nets that can be made.

The maths behind the exhibit



In Water Jet Challenge there is a water jet that launches a stream of water into the air. The water stream will travel in a curved path or trajectory. This curve is a shape that is symmetrical around its highest point, which is also known as a parabola. The exact size and shape of the parabola depends on the angle that the water jet is launched at.

You'll notice that when the water jet is launched at a low angle the parabola is very shallow and doesn't travel very far. As the angle increases towards 45 degrees the parabola gets higher and travels the furthest. When the angle goes above 45 degrees the parabola gets narrower and steeper, and the water doesn't travel as far. The exact position that the water jet hits depends on the angle that it is launched at.

A trajectory or flight path is the path that a moving object follows through space over time. The object might be a projectile or a satellite, for example. A trajectory can be described mathematically as the position of the object over time.

The maths behind the exhibit

There are five different puzzles in the puzzle area:

1 Tangrams
2 Rush Hour
3 3D Packing Puzzle
4 Towers of Hanoi
5 Pythagoras Puzzle

1 – Tangrams
Tangrams are ancient Chinese puzzles where an infinite number of arrangements can be made from seven shapes. There are only three different moves you can make with each shape. You can slide it into a new place, you can rotate it or you can flip it. The puzzle is to re-create a given shape using all seven pieces, without allowing the pieces to overlap.

2 – Rush Hour
The Rush Hour puzzle is based on a klotski-style puzzle. To solve puzzles such as this you need to visualise how the pieces move and what needs to happen next so that the route is clear for the red car to slide out of the grid. It's best to start by solving simpler puzzles first. These require fewer moves to solve, which means there's less forward-thinking to be done.

3 – 3D Packing Puzzle
The 3D Packing Puzzle is about combining pieces together to make a bigger 3D shape. Any 3D object has the three dimensions of height, width and depth. The cube you need to make is three pieces high, wide and deep. You need to visualise how each of the different smaller pieces will fit together to make this cube.

The maths behind the exhibit

4 – Towers of Hanoi

Towers of Hanoi is an example of a puzzle that can be solved by recursion. This means that if you work out the solution for a simpler version of the problem, such as for two or three discs, then you can extend the solution to solve a harder version of it, such as one with four or five discs.

5 – Pythagoras Puzzle

This puzzle is based on Pythagoras' theorem. First you need to arrange the pieces so that they fill the two smaller squares on the sides of a right-angled triangle. When both squares are filled you can take all these pieces and rearrange them to fill the biggest square along the longest side, called the hypotenuse. The area of the two smaller squares is equal to the area of the largest one. This demonstrates Pythagoras' theorem, which states that, for all right-angled triangles, the square on the hypotenuse is equal to the sum of the squares on the other two sides.