King Edward VI Camp Hill School for Girls

Maths Department Newsletter

18th July 2017

The biggest prime factor of $37^2 + 1 = 1370$ is 137

News

We were sad to hear, over the weekend, that the famous mathematician Maryam Mirzakhani has died from cancer at the age of 40. Because of this, we thought perhaps we should write one final maths newsletter this year, explaining who she was and what she did that made her famous.

The Fields Medal

Maryam Mirzakhani was the first woman ever to be awarded the Fields Medal, which is the most prestigious award in mathematics, since there is no Nobel Prize for mathematics. She won it in 2014 for "her outstanding contributions to the dynamics and geometry of Riemann surfaces and their moduli spaces."[1]

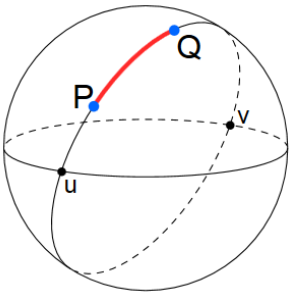
So, what's it like doing mathematical research?

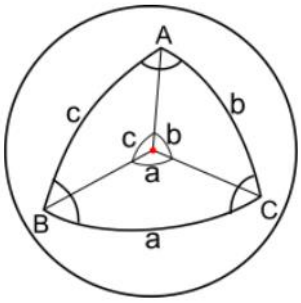
"In a way, mathematics research feels like writing a novel.
There are different characters, and you are getting to know them better. Things evolve, and then you look back at a character, and it's completely different from your first impression."

Maryam Mirzakhani

Maths Words

A **geodesic** is a straight line, and a **straight line** is defined to be the shortest distance between two points. On a flat surface, these are easy to picture, but on other surfaces, such as on the surface of a sphere, they become more complicated. When we define straight lines in this way, we discover some interesting things; like the fact that triangles drawn on a sphere, made of three straight lines, can have angles that add up to more than 180 degrees.





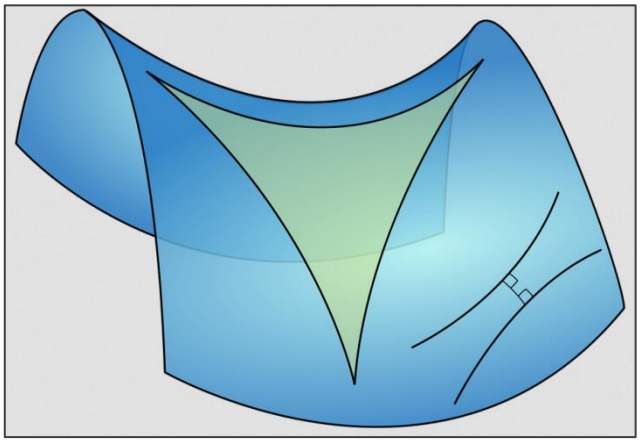
On a sphere, the shortest distance between two points is always part of a **great circle**, which is a circle whose centre is at the centre of the sphere. This is why a plane flying from London to New York flies over the Arctic.[2] Great circles are closed **loops**, and are called **closed geodesics**, unlike straight lines on a flat surface that are infinitely long in both directions and are not closed. So on what sort of surfaces will straight lines form loops and how many of those loops will there be? Could we even count them?

1. You don't have to understand what that means to understand the rest of this newsletter.
2. Remember, what looks like a straight line on a map will not usually be the shortest distance between two places.

Hyperbolic Surfaces

"As a child growing up in Tehran, Mirzakhani had no intention of becoming a mathematician. Her chief goal was simply to read every book she could find."

Mirzakhani became fascinated with hyperbolic surfaces, which are doughnut-shaped surfaces with two or more holes that have a non-standard geometry which, roughly speaking, gives each point on the surface a saddle shape.



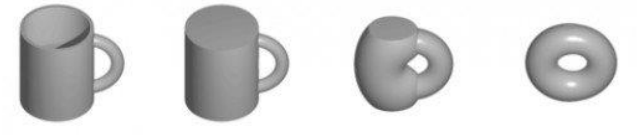
Hyperbolic doughnuts can't be constructed in ordinary space; they exist in an abstract sense, in which distances and angles are measured according to a particular set of equations. An imaginary creature living on a surface governed by such equations would experience each point as a saddle point.[3]

Mirzakhani became fascinated with studying hyperbolic surfaces. She was captivated by the beauty of the subject.

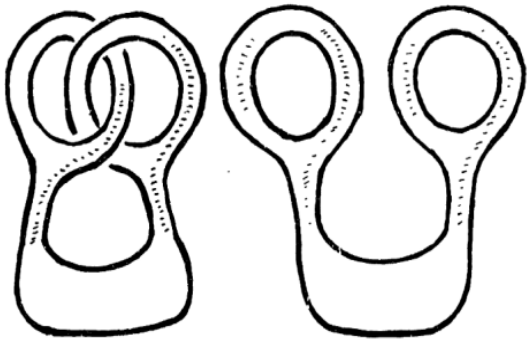
Some closed geodesics on hyperbolic surfaces are classified as 'simple', and in her doctoral thesis, completed in 2004, Mirzakhani answered the question of how many simple closed geodesics different kinds of hyperbolic surfaces have.

Topology

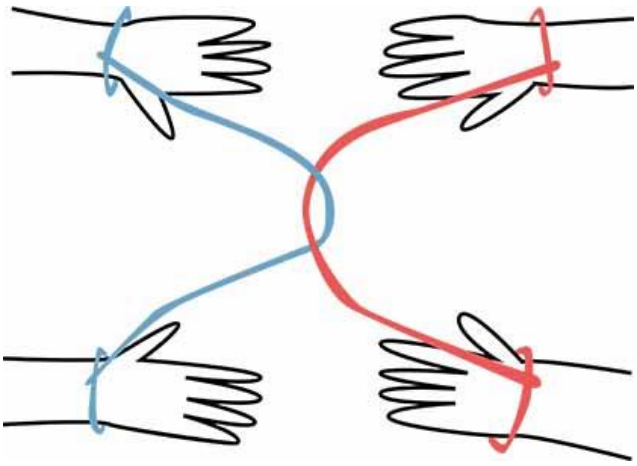
The study of surfaces is part of a branch of mathematics called **topology**. In topology, a coffee cup is equivalent to a doughnut, because you can transform one into the other just by stretching the shape.[4]



So here's a puzzle for you. Can you transform shape (a) into shape (b) just by stretching it? The answer is 'yes you can', but can you work out how?



Here's another puzzle. Yours and a partner's hands are tied together, and the ropes are entwined as shown in the diagram. Can you disentangle the ropes without cutting or untying them?



Perhaps, if you are bored during the holidays, you could try this one out. Let us know if you do.[5]

3. This is actually a proper mathematical term. Look at how the shape in the diagram looks like a horse's saddle. If you're not particularly familiar with horses' saddles, it's also the same shape as a Pringle.
4. You are not allowed to add or subtract any holes from the object.
5. You can probably find solutions to both of these puzzles on YouTube. Again, please let us know if you do.