

MATHEMATICS BEHIND THE MYSTERY OF A TRIANGLE!



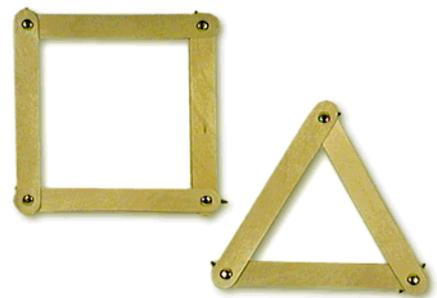
Have you ever heard about one of the seven wonders in the world, The Great Pyramid of Giza? If you were given a piece of paper and a pen, then you were asked to draw The Great Pyramid of Giza, what shape would you first ever draw?

Yes! It is a triangle! Hemiunu, who is the architect of the Great Pyramid of Giza, has applied the triangle shape for the main structure of the pyramid itself. But the main issue here, why did Hemiunu chose the triangle shape as the main structure of his great pyramid?

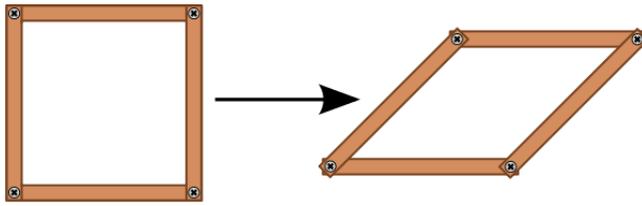
A triangle is a polygon with three sides and edges. It is one of the basic shapes in geometry. Based on Euclidean's geometry, the sum of the angles of a triangle is equal to a straight angle which is 180 degrees. We often heard people said that triangle has the strongest shape however we never know why and how. I found this a very interesting thing to know because as I walked past by the street, there is a lot more things were made up by triangles. The bridge, the buildings, the bench at the park, and many more.

Actually, a triangle has a very strong structure, not because of the material it made up from but it is because the shape itself cannot easily deform. Let say if we have two shapes, the common triangle and square made of wood and each of them have hinged corners as in the picture. Then we push at one side of the corner.

What will happen?



The square shape will slide and deform to a parallelogram shape. But the triangle will not



deform as the force exerted on it. Can you imagine it? You can try this at home and prove it by yourself! Make your own shapes

by using old cardboard box and combine it by using thumbtacks. You will see the same result as I did, believe me!

Why does this happen? Actually, there is the mathematics behind it. Do you ever heard the term 'degree of freedom formula, n'? This formula is to calculate the capability of rotations of two joints that attach together. It was given by Kutzbach equation degree of freedom which is;

KUTZBACH CRITERIA

- Kutzbach Criteria is for determining Degree of Freedom of body in Planar Mechanism (2D)

$$\text{DOF} = 3(L-1) - 2J - H$$

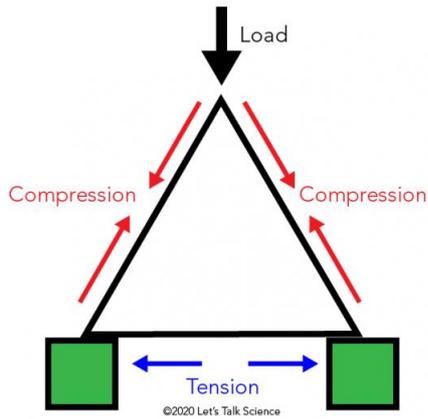
- Here:
- L = Number of Link
- J = Number Of Lower Pair
- H = Number Of Higher Pair

$$n=3(l-1)-2j-h$$

Where l is the number of links, j is the number of binary joints, and h is the number of higher pairs. When we substitute the number, where triangle has 3 number of links, 3 number of binary joints, and 0 number of higher pairs. Hence, we will get n=0.

Based on the calculation above, the degree of freedom of the triangle shape is zero. This indicates that links of the triangle shape can't move even a bit that makes the links strong enough even under the pressure of external forces. This also shows why the triangle structure did not flatten like the square shape.

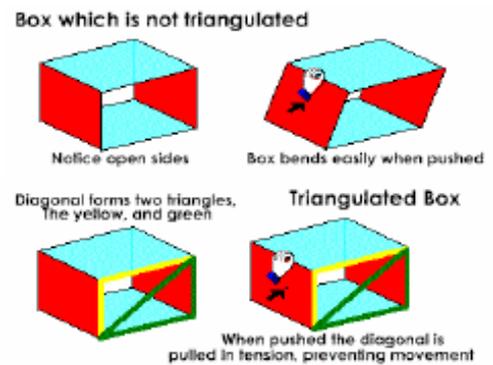
So, my fellow friends, that is the first factor why the triangle is a strong shape. Let's take a look at another reason why is it so. This might involve a little bit of physics but it's okay, physics and mathematics are somehow friends right?



Let's look at how a triangle distributes a force that acts on it. Whenever we applied any force at any corner of a triangle, the force will be distributed down each side. The two sides at the top will squeeze or in physics terms, it will experience compression. Then, the third side of the triangle will stretch sideways, or in physics terms, it will experience tension. In other simple words, we can say that the force

was distributed evenly at every side of the triangle. Therefore, whenever a force was applied to it, the force will not be concentrated at only one point and tend to break that point. This made the triangle is unbreakable.

As we can see, adding the triangle to a shape can strengthen the structure. As an example, if we have a square structure, and we knew it will bend to form a parallelogram shape as a force was applied to it. So, to make it a sturdy structure, we can just simply add the triangle shape in the square. As we can see in the picture on the right-hand side,



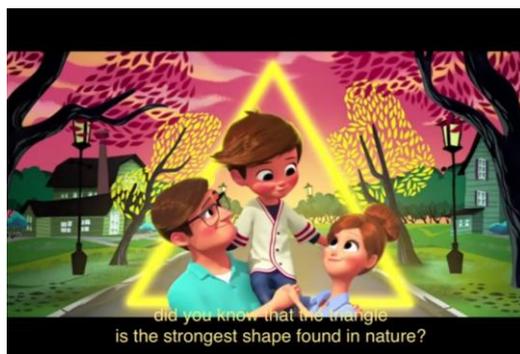
when we put the triangle structure in the box, the force that was applied on it can be distributed evenly and it preventing the movement. The same goes for any other shapes like circles, rectangles, or even pentagons!

Therefore, we can conclude that triangle is the strongest shape in geometrical history. Any weight that was put on it will evenly be distributed on all three sides of it. No matter how much force you put on it, as long as it was made of strong material, it will never break. That is why the triangle symbol is commonly used to represent something.



In ancient Christian symbolism, the triangle is commonly used to remind the believers about the trinity. The three sides of the triangles represent the three parts of the Trinity, the Father, the Son, and the Holy Spirit. These three-part come together to form one shape which is a triangle. Christian artists used the triangle as the perfect symbol for the trinity.

Triangle is also a symbol of a perfect family. Have you ever watch the animated movie called 'The Boss Baby'? You can see at the very starting scene of the movie, it tells you how the bond of a mother, father, and children can form a triangle which is the strongest shape found in nature and nothing can tear them apart. This is how a triangle can represent the strongest bond in the world which is the bond of a family.



So, our very first question of why Hemiunu used the shape of a triangle as the main structure of his Great Pyramid of Giza has been solved. It is because the triangle is a very rigid structure and as we can see, after thousands of years, the Pyramid is still standing majestically until now. The architects and engineers nowadays need to consider Hemiunu's idea in their masterpiece to make it as strong as The Great Pyramid of Giza.