HISTORY AND APPLICATIONS OF GEOMETRYIN REAL LIFE

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ABSTRACT: This study derives the study of geometry originated among various countries, ancient scholars derived geometry, and also these concepts of geometry are applied in our daily life. Geometry, as one of the most important branches of mathematics, has multiple applications. History of the relationship between geometry and humanity, to describe different applications of geometry and nature relates to geometrical concepts and designs is described more thoroughly in the article.

KEYWORDS: Mathematics, Geometry, Historical Geometry, Applications.

INTRODUCTION

The purpose of this article is to collect evidence of the study of ancient geometry found in different countries and cover some of the practical applications of geometry. Mathematical concepts are mainstream and so does geometric which also has varieties of real-life applications.

Mathematics is considered the language of gods. It sure plays a vital role in every field of study. At least everyone should understand basic arithmetic and geometric concepts to deal with day-to-day life problems. Mathematicians, engineers, and scientists solve complex problems to evolve science in order to make our life easier and more convenient. The theorems, properties, principles everything has some applications which are somehow connected to our day-to-day life problems. The purpose of learning mathematics is definitely fruitful. Algebraic equations are used for simplifications of complex problems, differential equations which help to derive several laws of physics and chemistry also used in the economy, biology, applied mathematics, engineering. Calculus also has wide applications such as calculations of physical quantities, statisticians use calculus in data analysis, calculations made in the construction of bridges and buildings. Applications are endless.

The world is very vast to talk about all the applications of mathematics, but here are some examples of general mathematics that we are familiar with. For example, managing

finance, calculating height, weight and distance, computer programming, estimating the weather, time, statistics, even cooking. As mathematics has uncountable applications, Geometry as an important branch of mathematics has many applications too. Geometry has been studied and progressed since ancient times. The world is dependent on geometric concepts, not only constructions of buildings but also computer programs, dynamic objects, different fields of studies, etc. Geometry is one of the oldest branches of mathematics that studies the properties and measurements of shapes and planes in different dimensions. With good knowledge of geometry, one can design anything more efficiently and perfectly, for example a bridge, infrastructure of cities, auto-mobile machines, and even interior designs. In modern life, designing skills are essential for being an architect, art director, and product designer.

In the history of geometry section, how geometry came into existence is derived with evidence. Evidence like designs in temples, drawing on rocks, symmetric patterns of buildings, ancient mathematicians' theorems found in countries like India, Greece, Egypt are described. It is true that geometryis evolved by the deep study of mathematicians who lived long ago in the above-mentioned countries. Egypt, one of the countries mentioned above, is also known for its world-famous pyramids, the Great Pyramids of Giza, which made the scientists and archeologists think deeply about how these pyramids were constructed. In the applications of geometry section how geometry is applied in life problems to make life easier is discussed which are based on my observations. We highly rely on geometric principles, as mathematics is applied everywhere.

HISTORY OF GEOMETRY

Geometry, one of the most important branches of mathematics, has its roots in countries such as Egypt, Babylon, China, Greece, and Vedic India. 'Geo' is a Greek word that means Earth merged with 'metric' another Greek word that means measurement makes the word Geometry. Geometry is largely derived from drawing pictures in the sand. Great thinkers used to draw various kinds of shapes like circles, rectangles, and triangles to study them. It was the Indians, Egyptians, and Babylonians who invented the study of geometry.

In India, the art of Vedic geometry is seen in the altars and sculptures of ancient temples and caves in India. Altars were designed with different shapes and curves which is aesthetically pleasant. These designs on temples as well as inside the temple are proof that designing along with geometry was studied in India for thousands of years. Evidence of

the geometrical designs is seen in the Indus valley civilizations which are 2500-1900 BCE which is around 8,000 years old. The beginningsof algebra are traced back to the structural geometry of the Vedic priests and are preserved in Sulba-sutra. Vedic Geometry majorly contributed to formulas of measurement of 2d and 3d shapes.

Figure 1: An inner structure of Indian temple

Baudhayana (800 BC - 740 BC)was a Vedic brahmin priest. He is the author of the earliest Sulba-sutra or BaudhayanaSulba-sutra. Another name of the Pythagoras theorem is BaudhayanaSulba-sutra, "Modern Historical Research has revealed that the Pythagoras theorem was known to Indians long before the time of Pythagoras." (Bharati, 1965)

Sulba means mensuration and Sutra means techniques together is Sulba-sutra, the only early sources of Hindu mathematical knowledge initially come from the Vedic period. “The Sulba-sutras are instructions on the construction of various geometric shapes used in the construction of "fire altars" and bases of buildings.”

Mathematics in China came into view by the 11th century BC. The Gou-Gutheorem, one of the basic and prominent theorems in geometry. The three sides which are a, b, and c of the right-angled triangle satisfies the following equation: $a^2 + b^2 = c^2$, where a is called 勾(Gou) and b is 股(Gu).

Jiu Zhang Suan Shu, One of the oldest and authoritative works in Chinese mathematics history, also known as ‘The nine chapters on mathematical art’. The nine chapters may be regarded as a Chinese counterpart to Euclid's Elements. Unfortunately, the original version of the Nine Chapters no longer exists. (Joseph, 1998)

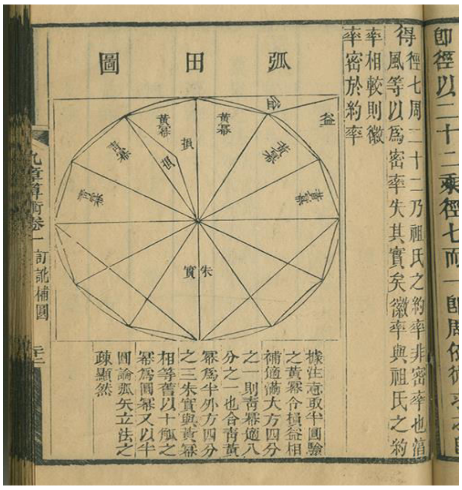

Figure 2: The nine chapters on mathematical art

In ancient Greece, studying geometry was considered the gold standard of their mathematical and scientific pursuits. The ancient Greeks didn't invent geometry but they studied it with great passion. Some ancient Greek mathematical scholars werePythagoras (570 BC - 495 BC)of Samos was a Greek philosopher as well as mathematician, he was also a religious leader. According to historical research, around 1900 BC Pythagoras came with his famous theorem.Aristotle (385 BC - 323 BC)born in Stagira, Chalcidice, Greece was an ancient Greek philosopher and scientist. Aristotle defined mathematics as the Science of Quality. He provided several examples of mathematical triads of terms in mathematics, for example, two right angles-angles about a point-triangle, or right angle-half two right angles-angle in a semicircle.Euclid (325 BC - 265 BC)is known as the father of geometry. He was born in Alexandria, Egypt. Euclid wrote 'Elements' consisting of 13 books that contributed to ancient Greek geometry. Euclidean geometry has two fundamental types of measurements i.e., angle and distance. The angle scale is absolute in position and the distance scale is relative. (John, 2011)

In Egypt, ancient Egyptians developed geometry from the 'Age of Pyramids'. The evidence of usage of geometry is seen on the walls of temples and written on papyrus. By studying these texts and diagrams archeologists came to know that ancient Egyptians were aware of several concepts of geometry. The Moscow Mathematical Papyrus is a well-known mathematical papyrus containing various problems in arithmetic, geometry, and algebra. It has twenty-five problems of which seven are geometry based. Some of the questions are computing areas of triangles, finding the surface area of the hemisphere, and finding the volume of a frustum. It is older than the Rhind Mathematical Papyrus which was named after Alexander Henry Rhind. It was found during the illegal excavation near

the Ramesseum. This Papyrus has several mensuration problems written on it, and now it is preserved in the British Museum. (Gregg, 2009)

One of the seven wonders of the world, the Great Pyramid is accurate in terms of its orientation, shape, and measurement. The Egyptian geometric tradition produced diagrams that attempted to represent three dimensions.

Figure 3: The Great Pyramids of Giza

The base of the Great Pyramid is a square, and each triangle representing each side of the Great Pyramid is an isosceles triangle. In addition to all the calculations that were used to create the pyramid, an important scroll was also used, the Rhind Papyrus. By the measures of the Great Pyramid, we find that the side of the triangle exhibits golden ratio proportions or 1:1.618 (Φ). According to various studies in the past, the Great Pyramid has a base of 230.4 meters and a height of 146.5 meters. The half of the base of the pyramid is given as 115.18 meters, therefore by Pythagoras theorem

(146.515)^2 + (115.182)^2 = 34,733.5383 = 186.3 meters, also known as apothem. We get the golden ratio(1.618) by dividing the apothem, mathematically it is 186.368 / 115.182 = 1.618 which is Φ up to 5 decimals.(Christopher, 2014)

In Babylonia, Ancient Babylonians used studies of triangles techniques 1500 years before Greeks. According to a study, the result shows that the ancient Babylonians were using geometrical calculations to track the biggest objects in space.

The Plimpton 322 tablet, An Ancient Babylonian tablet was revealed which has the world's first trigonometric table which is 3,700 years old. The preserved quantity of the tablet is approximately 13 cm wide, 9 cm high, and 2 cm deep. The numbers on the Plimpton tablet are written in the cuneiform script using the sexagesimal number system (a

number system with base 60, originated in 3rd millennium BC). The Babylonian number system is not a pure sexagesimal system in the modern sense of the word. The digits from 1 to 59 are expressed using only two symbols.

Figure 4: The Plimpton 322 tablet

GEOMETRICAL ASPECTS IN NATURE

Nature defines beauty as geometry and in fact, geometry is created by nature. Geometry is the discipline to express patterns. The appearance of geometrical patterns is not rare, we see them often everywhere in our environment for example, the shape of honeycomb follows hexagon patterns, symmetrical patterns in the center of flowers, the spider-web, pentagon shape of Okra or ladies-finger, different patterns of a snowflake, scales on reptiles, noteworthy spirals of seashells.

Figure 5: Honeycomb

Coil-like patterns of galaxies, the elliptical orbits defined by gravitational force, the beauty of the horizon, and many more. The optical illusions which are recurring of similar patterns in a frame have a psychological impact. This concludes that Geometry is the art of nature.

APPLICATIONS OF GEOMETRY

In Architecture, the architects use geometric perspective which is a drawing technique. To draw perspective, one should have good knowledge about lines, angles, and basic shape properties. There are various methods of perspective one-point, two-point, and three-point. One-point is the simplest method and is used for interior spaces. Whereas two-point perspective is dynamically used in the representation of exterior spaces.

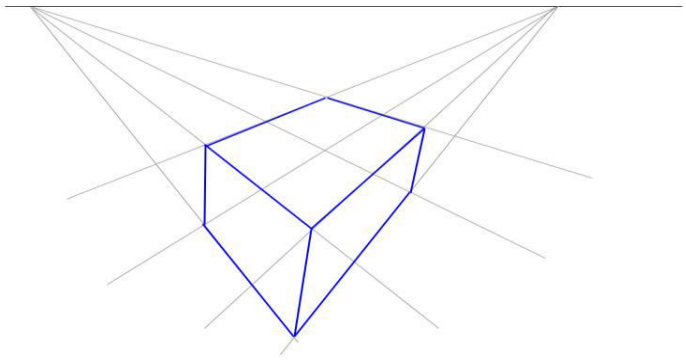

Figure 6: Two-point perspective

The three-point perspective method is complex and used to illustrate long-range views. Architects first draw the blueprint of their main project. The blueprint is drawn with lines and angles with proper measurements which helpsto analyze the errors in the design. (Cornelie, 2006)

Geometry is an imperative treasure in the computer world, Geometrical principles are used in a game's basic programming and also in graphics. Suppose a character is jumping from a specific height, it will look more pleasant when that character's jump is curved shown in example 2, and not linear shown in example 1. To achieve the curve, the concepts of coordinate geometry are used by plotting the potential locations in a curved path.

Video games rely on geometric principles. The player's view, terrain design, graphics, game motions, objects are geometry itself. Terrain, which is the background of the scene and is made up of Polygons. Polygons are nothing but closed plane figures which have 3 or more than 3 straight lines.

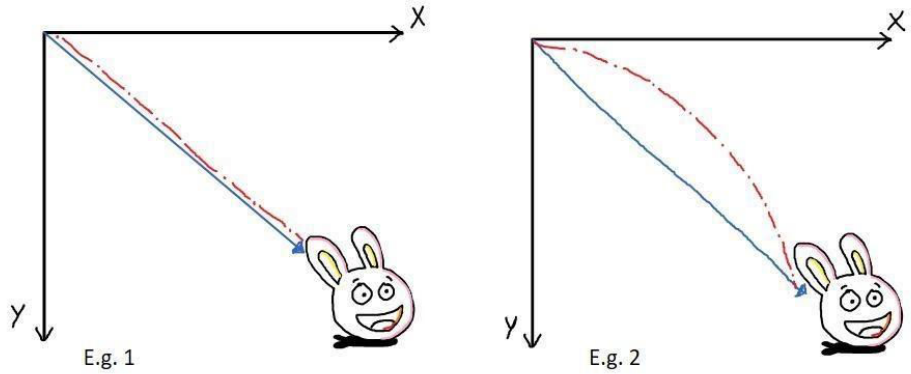

Figure 7: Example of Linear path and Curved path

Game developers define the position of objects using vectors. In 2d games, the axes X and Y are used to represent the position of the object. Suppose the character is on point (2,1) and we want to move it, here where the vector defined in the program changes to (2,2) which will move the character in that specific direction. The properties of the objects in the game are also made up of vectors. (Dan, 2000)

Animators use geometric principles to make objects look more precise. Computer animation software basically uses polygons to create everything on the screen. Vectors and trigonometry play a role in moving objects, smooth transformations, collisions, and even in calculating a trajectory.

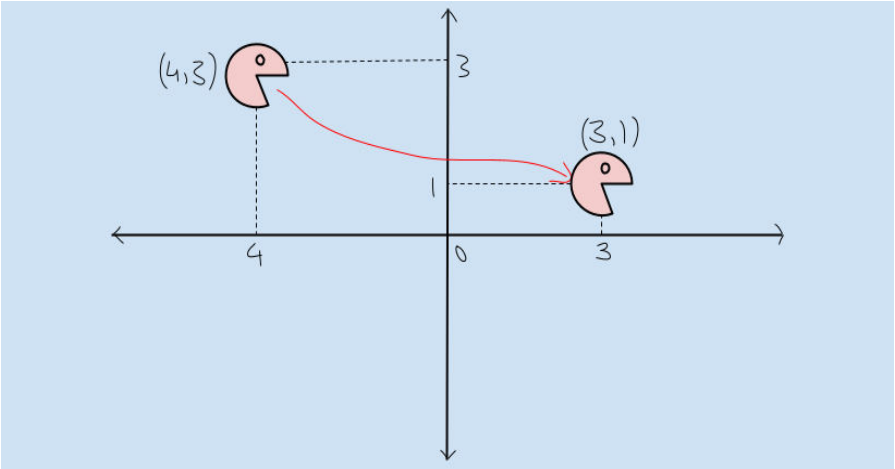

Figure 8: Example of Animation

To make objects move on the screen, animators use coordinate geometry. For 2d animation as shown, the object is placed on x-intercept and y-intercept and then the values are changed. (Hector, 2003)

Complex responsive websites which are written in HTML (Hyper Text Markup Language) and are designed by CSS (Cascading Style Sheets) have geometrically structured grids.

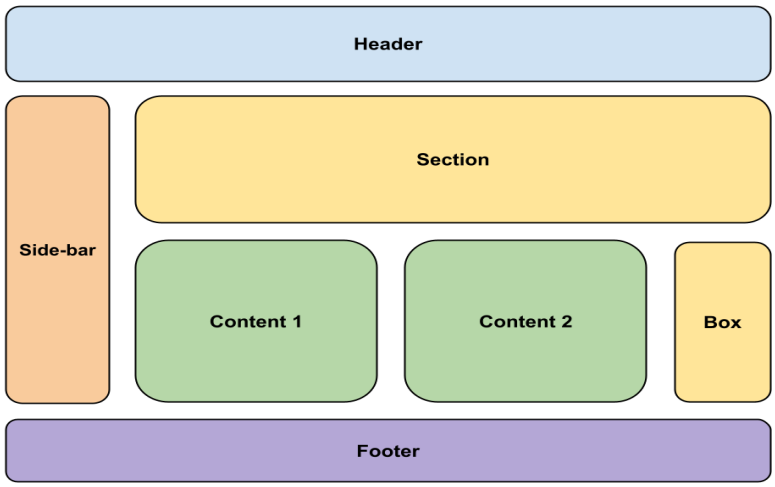

Figure 9: Example of CSS Grid

Programmers make use of CSS Grid and CSS Flexbox layout modules which automatically adjust their size according to the resolutions of different devices. These modules are actually programmed with geometrical principles and are highly consistent.

In sports, every game played in sports whether it is soccer, kabaddi, basketball, volleyball or badminton, etc. has rules. These games are played on the ground and the teams must be approximately equal in strength. The playgroundsare designed symmetrically. The playground is made up of several shapes and angles on which the rulesets are based. In archery, the archer calculates the trajectory distance with his/her geometrical skills to aim at the target. Sports players make perfect use of angles to shoot a soccer ball, toss the ball in table tennis, and throw the ball into the basket, everywhere geometry is being applied.

Geography is the study of different regions and geometry is an important asset used by geographers in their study. Maps are where cartographers make use of geometrical skills the most. Maps are handy for explorers and making a map requires geometrical skills. Skills like adding proper scale in both directions for 2-dimensional maps, alignment of different objects, drawing the proper size of the region to compare it with other regions are needed to make a good map. Coordinate geometry, graphical drawing, scaling, etc. are fundamental geometrical concepts for geography.

The ancient Indians and Greeks used geometry to study celestial bodies. The average person from outside the field of astronomy does not need a degree in physics to track and calculate the distances to stars and other celestial bodies in space, with the proper

principles of trigonometry. Applied to the right situations, one can easily determine the positions of stars and planets. The telescopic model deals with parallel rays, angles of reflection and refraction.

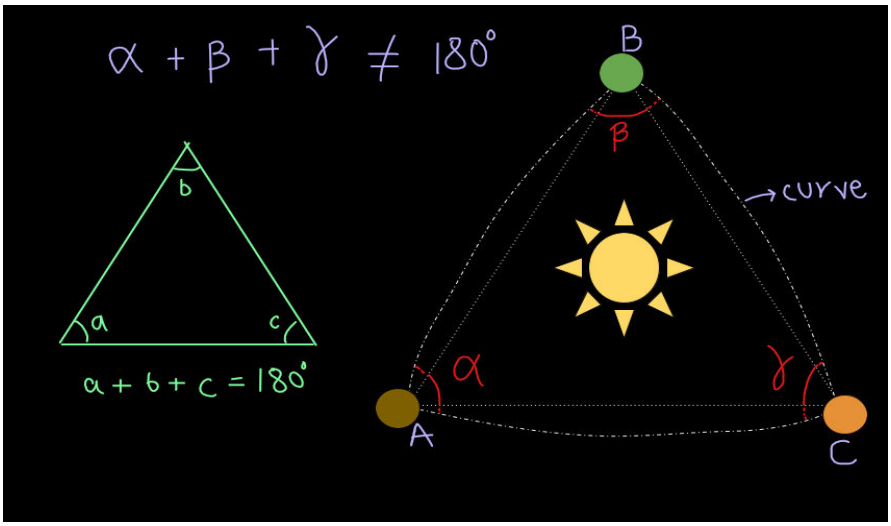

Figure 10: Example of General Relativity

In general relativity, Albert Einstein used the property of the sum of triangles theorem, which states that the sum of the interior angles is 180 degrees. Consider three stars as light sources on points A, B and C. Usually they will form a triangle. But according to general relativity, space curves in the presence of some mass. In this case, there is the sun in the middle of the triangle with a mass of 1,891 × 1030 kilograms. The greater the mass, the greater the gravity. This gravitational field causes the curvature that is responsible for the curvature of starlight. Hence α + β + γ ≠ 180 degrees.(The general theory of relativity, Albert Einstein)

CONCLUSION

The more we move forward the more we understand that the applications of geometry are magnificent. Mathematics itself is a beautiful subject. It's really fun to observe that the letters we use to write are also made up of lines, curves. For thousands of years, mathematics has progressed whose study led us to understand the mysteries from the core of the Earth to the universe. In the history of geometry section with lots of evidence it is proved that geometry was a very important field of study.

Everything relies on concepts of mathematics. As discussed in this article, geometric skill is an important asset in many fields. Many structures, monuments, and buildings from the ancient era are still standing because they were skillfully constructed from that time.

Today in the modern world due to advanced technology constructing almost everything from buildings to furniture, even toys are computerized.

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