

## An Analysis on Using and Understanding Mathematics as a Science to Portray Different Visual Art; A Study.

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**Abstract:** The paper traces the importance of Mathematical Concepts like Algebra, Geometry and Trigonometry, in the visualisation of an artist's mindset; whether it is the early European artists in the fifteenth-sixteenth century, who were part of the Renaissance Impressionist and Cubism Period or the Indian Sculptors who were part of the ninth-tenth century. Even today, the scope of Mathematics as a science in art is extremely relevant and important, in the depiction of various art forms that an artist wishes to portray.

**Research Question:** The paper will attempt to analyse various concepts of mathematics in the presentation of certain dimensions while depicting various themes on canvas. A study on the knowledge of mathematics in this field becomes imperative, especially when the artist is trying to portray his ideas which requires three-dimensional figures. Do all artists use mathematical skills? Are mathematical skills engrained in their conscience and is it automatically depicted on canvas? These and other such questions would be attempted in the course of the paper.

**Key words:** Geometry, Trigonometry, Renaissance, Perspective, Golden Ratio, Woodcut, Cubism, Expressionism, Pop Art, Sculpture, Bombay Progressive Artists Group, Temple Architecture.

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### I. Introduction

Mathematics is a wide scientific field and can be discerned in arts, such as music, dance, painting, architecture, sculpture and textiles. One of the earliest known painters who used the science of Mathematics extensively in his art was Albrecht Dürer, also regarded as the greatest German Renaissance Artist. His paintings and engravings show the Northern interest in detail and Renaissance efforts to represent the bodies of humans and animals, accurately.



Figure 1 : Albrecht Dürer, Copper Plate engraving  
*Melancholia I* (1514)  
Source: Daily Art Magazine

He produced three hundred prints, throughout his artistic career, mostly woodcut and engraving. Woodcut paintings use knives and other tools to carve a design into the surface of a wooden block. This image leaves only some areas at the original level. The concept of wood-carving and wood-art requires precise geometric shapes. The final result is not only aesthetically pleasing but also conveys a sense of order and harmony.



Figure 2 : The Printed Image in the West: Woodcut  
Source: The Metropolitan Museum of Art

Renaissance art (1352-1620 AD) includes paintings, sculptures, and decorative arts of the period of European history known as the Renaissance (rebirth). It describes the revival of art that took place in Italy from the 1400's, under the influence of the rediscovery of classical art and culture. Leonardo Da Vinci (1452-1519) was regarded as the Greatest Renaissance Painter. He was one of the most influential figures, not only of the Renaissance but of art history itself, providing unparalleled insight into a huge range of fields from art and mathematics, to engineering and astronomy. Michelangelo and Rafael were the other names of Renaissance art. The following figures indicate a close relationship between mathematics and art,

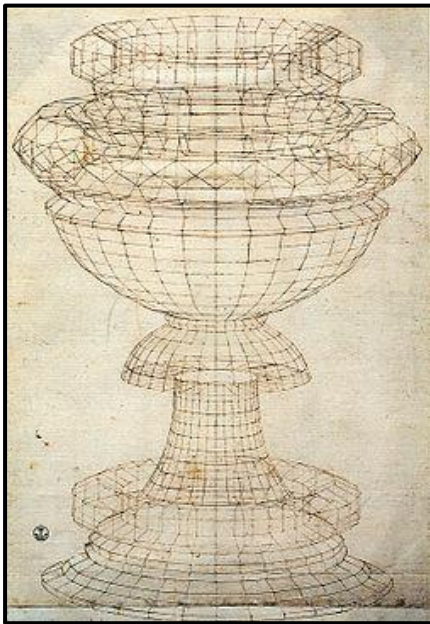


Figure 3a: wire-frame drawing of a vase  
Source: Wikipedia

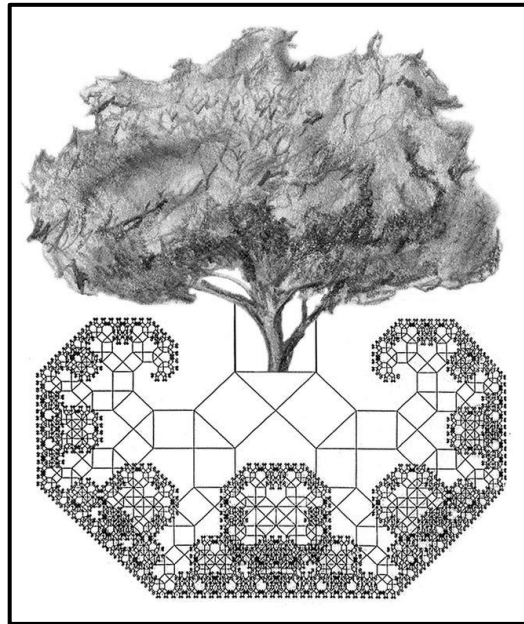


Figure 3b: The square root of a tree  
Source: Sarasota Herald Tribune

Figure 3a is a vase that was painted by Paolo Uccello in the 15<sup>th</sup> century.

Figure 3b, Stephen Ornes studies geometry in motion to the possibilities of pi ( $\pi$ ). According to his revelation, art has been inspired by the beauty and poetry of mathematical principles. He, in his volume has presented a number of pieces, including a crocheted, colourful representation of non- Euclidian geometry that looks like a sea coral and a sixty five tonne, twenty eight foot tall bronze sculpture, covered in space filling curve. All his works have been substantiated by thought provoking explanations, of the mathematical concepts and equations behind the art.

## II. Background of the science of mathematics and its impact on art.

Artists have used mathematics since the 4<sup>th</sup> century BC, when the Greek sculptor Polykleitos conjectured proportions to have been based on the ratio of  $1:\sqrt{2}$ , for the ideal male nude. There have been claims that the Golden Ratio have been used in ancient art and architecture. Leonardo Da Vinci used the Golden Ratio ( $\phi$ ) on woodcuts. A golden ratio is the ratio between two numbers which equals to 1:1.618.

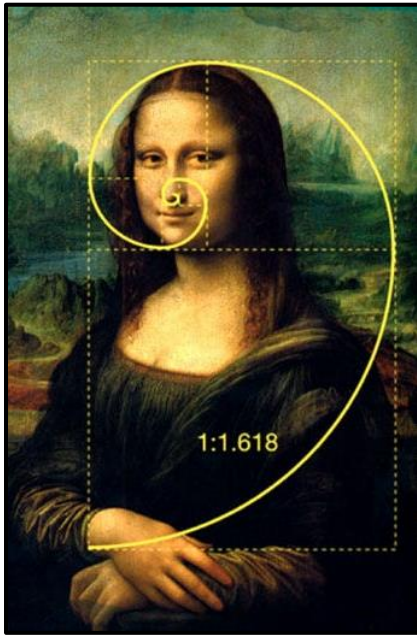


Figure 4: Golden Ratio used in Leonardo Da Vinci's Mona Lisa

Source: Vicky Nimbalkar - Medium

Besides Leonardo Da Vinci and Albrecht Dürer, who made many references to mathematics; in modern times, graphic artist M. C. Escher has made intensive use of Tessellation and hyperbolic geometry, Piet Mondrian embraced geometrical forms. Mathematics has inspired textile arts such as quilting, knitting, cross-stitch, crochet, embroidery, weaving Turkish and other carpet making. Islamic art has symmetries in Persian Girih and Moroccan Zellige tile work, Mughal Jali pierced stone screens are also prevalent.

Mathematics has directly influenced art with tools like linear perspective (a system of creating an illusion of depth on a flat surface.)

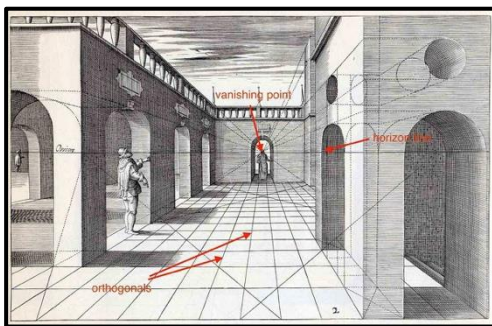


Figure 5: Linear Perspective in architecture

Source: The Collector

Analysis of symmetry as well as mathematical objects such as polyhedra, and the Mobius Strip have been extensively used by some Renaissance artists to indicate challenging models and their mastery of perspective.

Other mathematical concepts that were employed were fractals, including the Mandelbrot Set, Cellular Automata, Camera Lucida, Camera Obscura, Algorithmic analysis of artworks by x-ray fluorescence spectroscopy. Traditional Batiks have Fractal dimensions being employed. Pythagorean notion is used extensively in the notion of harmony in music. According to this theory, everything was arranged by a number and that God is the geometer of the world, and thus for the world geometry is sacred. The use of the science of mathematics has been commonly used by artists from time immemorial, in some cases it has been intentionally used, while in others unintentionally.



### III. Contemporary artists using mathematical concepts in depicting various art forms.

Normally, there are three significant art forms which can be stated in the following manner:

- Painting
- Sculpture
- Architecture

Painting, as an art has been in existence since prehistoric times where humans have been creating art, through different forms and media. The majority of cave paintings and rock shelters, across the world have become important heritage sites under UNESCO, to preserve cultural history and uphold the maintenance and regulation of these archaeological sites. From prehistoric cave paintings to architecture of ancient Greece and Rome, art has played a huge role in personal and public life. Paint that has been used over time, consisted of a pigment combined with a binding agent, oil, egg or water, and possibly a filler to make the quantity substantive. In ancient times, artists relied on natural materials such as plants, bones, ochre and charcoal to paint. But today, artificial colouring is the primary choice, which is not only user friendly and convenient, but also environmentally safe. The type of brushes that are used have also changed overtime, besides brushes fingers, knives, spray cans, sponges are used to engage in paintings. The different type of art has been classified and developed by the French Royal Academy, that includes:

- Still life
- Portrait
- History
- Scenery
- Figurines
- Abstract

These provide us with a glimpse into history, that enables humans to understand the life before the present existence. It also helps in understanding the political and social scenario during that period. Paintings are also classified into one or several 'art movements' which depend on the underlined philosophy that determines the style, content and subject matter of the paintings as well as their temporal location, in relation to previous art movement.

Well known art movements that started in Europe include:

- Expressionism (1905-1920): Abstract expressionism – Jackson Pollock. A large number consider abstract paintings to be extremely influential as it employs a variety of art forms, as well as media to convey abstract visuals and themes. Artist and physicist Richard Taylor (University of Oregon), indicated that Pollock's eccentric painting style is based on a pendulum. When this pendulum is oscillated slowly or at a very high speed intentionally, it creates a type of chaotic motion which may accurately describe Pollock's painting style. This artist's work could also be looked at as representing 'Fractals', different sections seen at different distances have the same amount of visual complexity. Gravity also played a central role for Pollock and nature. He is also very famous for, what is known as 'drip painting'.

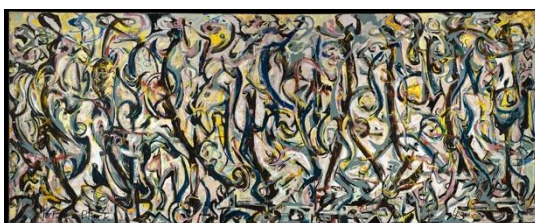


Figure 6: Drip Painting by Jackson Pollock

Source: The New York Times

The Russian artist Wassily Kandinsky created abstract paintings using mathematic concepts like concentric circles and geometric shapes.

- Impressionism (1867-1886): Famous artist at this time was Claude Monet, who is known for his mastery in his use of colour. Monet's compositions involve intricate details which adhere to the concepts perspective and spatial arrangements. These concepts can only be achieved with the aid of concepts governed by mathematics such as proportion and geometry.
- Pop-art movement, in the USA (Mid-twentieth century)Pop Art is one of the largest Art movement's in Art history, that drew inspiration from commercials and pop culture to create bold pieces, that reflected the realities of everyday life. It was a revolt against elitism and traditional artistic norms, and also a response to capitalists and consumerism culture in post war – America. The images that were painted definitely needed

knowledge of mathematics to be in a position to correctly draw comic figures and other such figures to depict reality. For large scale Pop Art installations, different rules of structural engineering are kept in mind in order to ensure the stability and durability of a structure, by calculating the strength of materials and stress distribution. This is done using various different mathematical principles.

- Cubism & Realism (in the twentieth century): an example of Cubists was Pablo Picasso. He was one of the most influential artists of this time. In art, Realism aims at capturing objects in their truest form on paper, while Cubism is mainly directed towards depicting objects from different perspective, thereby breaking them down into geometric shapes; these can even be verified using the basic principles governed by mathematics. Picasso often used these geometric shapes and patterns in his Cubist works, to create dynamic and eye catching pieces of art.

- Renaissance: (1400-1600) an example of a Renaissance artist was Leonardo Da Vinci, this artist used mathematical thinking to carry out his artistic vision. In the renowned piece of art, “Mona Lisa”, which has been drawn according to the golden ratio, which is, as indicated earlier  $1 : 1.618 (\phi)$ . It is called “Golden” as it is aesthetically pleasing.

A piece of art was created in 1580 that uses anamorphic art techniques, for example: if you look from one point, Mary Queen of Scots is recognizable and moving to another point, one finds that a skeleton has taken her place.

- Surrealism (1924-1966): Salvador Dali, an artist known to have achieved mastery in this field, has created visually striking thought provoking pieces of art which make one question the boundaries that separate reality and imagination from each other. Believing in the aesthetic significance of the Golden Ratio ( $1 : 1.618$  or  $\phi$ ), he extensively used it in his art work. His works also made of non-Euclidean geometry in order to create distorted perspectives to blur the lines between reality and fantasy. Further, in order to add layers to his surrealistic compositions, he makes use of a variety of mathematical symbols including fractals and hypercubes.

- Art forms like Collage are used to create visual narratives as an element of painting or assemblage. In order to arrange, organize and implement different elements with a collage, artists extensively use geometric concepts of symmetry, grids and patterns. Further, to ensure the harmonious implementation of different components, artists also use different scales to determine their proportions.

- Sculpture is an ancient art form which involves the creation of art in three dimensions, the material ranges from clay, metal, bronze, marble and wood. The processes used include modelling, casting, assembling and carving. Mathematics is deeply interrelated with sculpting; from determining proportions and scale to the reliance of geometrical concepts and comprehending three dimensional space.

Sculptures can be freestanding for example: *Christ the Redeemer, (1931), in Rio De Janerio by Paul Landowski.*



Figure 6: Christ the Redeemer by Paul Landowski

Source: The Collector

Sculpture can also be executed in relief, for example: Mount Rushmore (1927-1941)

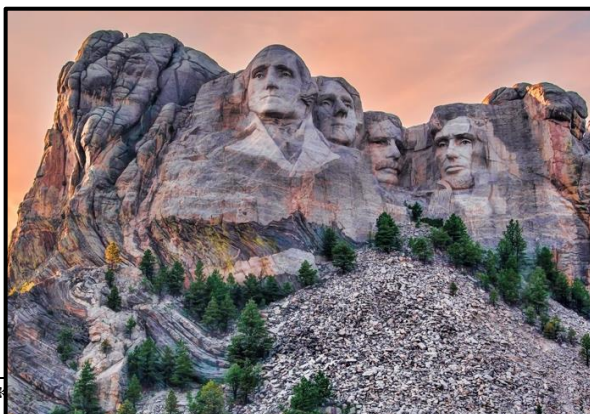


Figure 7: Mount Rushmore - Lincoln Borglum and Gutzon Borglum

Source: Heritage Daily

Sculptures can also be in elaborate forms, for example: carved into the temple complex at Khajuraho in India.



Figure 8: Khajuraho Temple Complex

Source: Cultural India

Sculptures may include other forms of art, in the form of decoration or embellishment. The Statue of Liberty (1886), is a modern example of sculpture that has become world famous.

The two types of art that use pattern and illusions are *Tessellations* and *Anamorphic Art*. Tessellations are a group of shapes, tiled to form a continuous pattern on an infinite plane, an example would be from the work of M.C. Eschers.

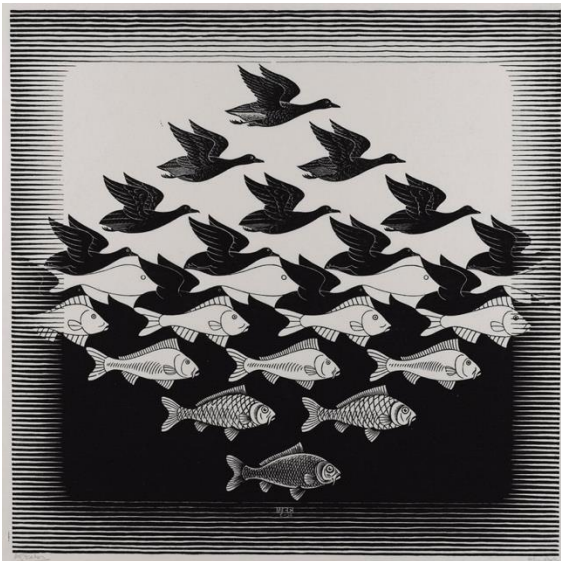


Figure 9: Use of Tessellations in the Art of M.C. Escher.

Source: The Museum of Fine Arts.

Anamorphic Art appears differently from different perspective; it maps the points of a three dimensional object on a two dimensional plane to create a picture that looks like it could be stepped into. This is also used in photographs and sculpture.

Installation art is connected to sculpture and performance art, that involves artists arranging objects and artworks in a site-specific space to ensure the message of the artwork is received and understood.

Architecture is another form of art that has a distinct aesthetic quality and could also have a close relationship between utility and beauty. Famous examples of architecture are Pyramids in Egypt, Colosseum in Rome, Taj Mahal in India, Leaning Tower of Pisa in Rome, Eiffel Tower in Paris, Le Louvre in Paris. Different forms of architecture can be broadly divided into:

- Classical Architecture
- Renaissance Architecture
- Gothic Architecture
- Baroque Architecture
- Neo-classical Architecture
- Bauhaus Architecture



- Victorian Architecture
- Modern Architectures
- Post-Modern Architecture

In all the aforementioned types of architecture; geometry, algebra and trigonometry play a crucial role, architects plan these mathematical concepts to plan their blueprints and sketch their designs. There is a great deal of understanding involved in the array of dimensions, quantity, area, volume for special planning and patterns. Mathematical modelling enables engineers to understand the behaviour of systems, predict outcomes and optimize design before entering into physical construction. In this field, the performance of the material used has to be evaluated mathematically with the overall design, before entering into the building stage.

#### **IV. Case study of Bombay Progressive Artists' Group (PAG) and their effective use of mathematics in portraying their art work.**

The PAG was a group of modern artists, mainly based in Bombay and it was formed in 1947. The group was ostracized by the Indian Art Establishment; and were compelled to stage their own exhibitions and events. Primarily, they were financially aided by an Expressionist Painter in Europe; Walter Lang Hammer. They did not follow one particular style, though it seemed that there was a synthesis of influences from Indian Art history, and styles prevalent in Europe and North America, during the first half of the 20<sup>th</sup> century, including Post-Impressionism, Cubism and Expressionism



Figure 10: The Bombay Progressive Artists' Group

Source: Artisera

The six founding members were F.N Souza, HA Gade, SH Raza, MF Hussain, KH Ara and SK Bakre (sculptor). The others who got associated with the group were Ram Kumar, Akbar Padamsee and Tyeb. This group was different from the Bengal School of Art which was prominent, at that time. They founded their group months after August 1947; claiming that the partition was an impetuous for new standards in visual art, in independent India. This resonated with the Freedom Movement and their intention was to paint with absolute freedom with the respect to content and technique.

In 1950, SH Raza, FN Souza as well as SK Bakre migrated to the UK. Artists like Vasudeo Gaitonde, Krishen Khanna and Mohan Samant and Bhanu Athaiya; associated themselves with the group. European Modernism was a distinct influence of this group.

Souza: famous for figurative work, often distorted, aggressive and sexualised. His work exhibited geometric abstraction, precise proportions and structured compositions; showing his deep understanding of mathematical principles which have clearly been incorporated in his works. Souza's works reflect a combination of different inspirations; showing his unique perspective and mastery of the form.



Figure 11: Crucifixion by FN Souza

Source: Tate

MF Hussain was a self taught artist and started his career by painting cinema posters, and designing furniture and toys. His works celebrated all things Indian, and drew inspiration from Indian Mythology, history, nature and urban spaces. His training was in Mathematics ,Geometry and Measurement; which he used effectively in his paintings such as the portrait of Ibn Zainab, Arjun and Sudarshana Chakra, Cyclonic Silence and others.



Figure 12: Arjun and Sudarshana Chakra by MF Hussain

Source: Artiana

HA Gade was one of India's earliest Abstract Expressionist painters, consisting of landscapes, rural scenes and still life; which were based on concepts of Geometry and Space. Geometric forms, in his works, are overlaid to convey a dense cluster of structures. Gade's landscapes have often displayed an accurate perspective and proportion to real life objects/dwellings. Through precise usage of elements and alteration of scale, he has managed to encapsulate on paper – compositions, that draw the viewer's eye into the scene.

Krishen Khanna's works are primarily figurative, which definitely uses the knowledge of Geometry, to effectively convey his feelings. His work displays a balance, with carefully arranged elements and constituents. Although these aspects relate more strongly to aesthetics, principles of balance and proportion may have different underlying laws of mathematics being incorporated including the Fibonacci Sequence or the rule of thirds.



Figure 11: Bandwala by Krishen Khanna

Source: National Gallery of Modern Art

Padamsee explored specific styles and themes, and intensively uses a range of media from oils on canvas to computer graphics and films. His work indicates a large number of geometric styles. Similar to most artists, Padamsee too was compelled to develop an understanding of the principles of perspectives and proportion to create eye catching compositions. These artistic principles involve different underlying mathematical concepts, in order to maintain precise scale and proportion.

#### **V. Use of mathematics in Ancient Temple Art in India.**

The key source for Hindu Temple Architecture is derived from the Mathematical Geometry; *Vastupurusha Mandala*. Thus, the structure of the temple building acts as a single human body, it is a metaphysical philosophy beyond reality. Hindu texts like Epics; Puranas, Vedas.etc inculcate the subject called



*Vastu* which plays a vital role in the construction of temples and building structures. The formation of any ancient building structure is related to terms of units which can be evaluated and fixed easily with the help of traditional system of measurement. The importance of traditional measurement is rigid in the understanding of the geometry used in the structure.

Mathematics has always been at the forefront; going hand in hand with temple architecture, giving it perfect shape and geometry, for the holistic development of society. Modern Temples being constructed today with archaeology need to look at the mastery of mathematics and art with which the ancient temples were built. Most prevalent examples are in Khajuraho: The Kandairya Mahadev Temple, which is the largest, tallest and most ornate among the western group of temples in the city built by the Chandela Rulers (950-1050 CE), it is the best preserved temple of the medieval period of India. Endless mathematical concepts have been used to form the Kandairya temple; including trigonometry, which have been specifically used to calculate angles and proportions in the design of its different features such as the shape of the Shikhara (spire) and the placement of the innumerable decorative elements. Some mathematical elements incorporated are said to even have religious and metaphysical significance in the context of Hindu Temple Architecture, for instance, some of the numbers and geometric shapes used in the Temple's architecture have been used due to their auspicious and sacred associations.



Figure 12: Kandairya Temple

Source: Go Kshetra

Charminar was built in 1591 CE in Hyderabad by Muhammad Quli Qutub Shah – the 5<sup>th</sup> Sultan of the Qutub Shah Dynasty. The Charminar is considered both; a monument and a mosque, and is believed to have been built to commemorate the end of a widespread plague during that period. It is built on a square structure that has four grand arches and four minarets. The number “chaar” or four, and its multiples can be figured in at least twenty two spots in the design of the structure. The Charminar exhibits a high degree of adherence to the principles of symmetry and proportions; determined using mathematical concepts. Symmetry in the structure's layout contributes to its aesthetic appeal and structural stability. The Charminar's architects have used different geometric principles to determine the proportions and dimensions of its different components, including its arches, domes and balconies.



Figure 13: Charminar

Source: India Currents

Modhera Sun Temple dedicated to “Surya” is situated in the Mehsana District of Gujarat, and was built in 1026 CE by King Bhim Dev – a Sloanki King, on the banks of the river Pushpavati. It has fifty two heavily carved pillars, signifying the weeks of the year, a mundap divided into seven sections, signifying the days of the week and a panel of three sixty five elements on the base of the temple, signifying the number of days in the year. Aligned with astronomical phenomena of equinoxes, the Modhera Sun Temple uses calculations to

determine its orientations and alignment, while keeping celestial events in mind, thereby reflecting on ancient beliefs and cosmological concepts.



Figure 14: Modhera Sun Temple

Source: Times of India

Samrath Yantra- the world's biggest stone sundial, standing at seventy three feet high in Jantar Mantar in Jaipur; Rajasthan, it is an astronomical instrument built by King Sawai Jai Singh II. It is known for its precision in measuring time, and tells of the local time with an accuracy of 2 seconds, using the shadow cast from the sunlight. The structure consists of a massive triangular gnomon (shadow casting device), which is placed on a rectangular base. Due to the earth's curved shape, it can be clearly inferred that spherical trigonometry has been used to make a precise calculation of the sun's position, with respect to the observer's latitude and longitude.



Figure 15: Samrath Yantra

Source: Jantar Mantar

Sundial at Konark Sun Temple in Puri, Odisha. The wheels of this temple are used to calculate time to the accuracy of a minute, including day and night. This sundial is unique as it shows time anticlockwise. It has eight major spokes that divide twenty four hours into eight equal parts which means the time between two major spokes is three hours. Since the sundial is closely linked to astronomical observations, specifically the apparent motion of the sun across the sky, mathematical calculations (related to astronomy) have been used to find the inclination of the shadow casting device and the placement of the sundial's markings, in order to align with the sun's path. Additionally, mathematical conversions are required to translate the sun's angular position into local time readings.



Figure 16: Sundial at Konark Temple

Source: World Press

## VI. CONCLUSION

Research has clearly indicated that Mathematics was widely used by most of the world artists in depicting their inner feelings on various subjects. It has been shown that whether it is Lenoardo Da Vinci or MF Hussain, or even the ninth century sculptors who built the Khajuraho Temple Complex, all of them incorporated various concepts of Math; primarily algebra, geometry and trigonometry to give vision to their artistic works. Considering that we have mentioned art that has been alive till the twenty first century, indicating the importance of Mathematics as a science in its survival.

To understand the importance of this science in art, all the latest art forms like the NFT (non-fundable token), which is digital art, that is stored through the block chain technology medium, indicating distinctly the importance of Mathematics, even in the newer art forms.

### Bibliography:

- [1]. Chaki, R. (2020, April 9). How an ancient Indian art utilizes mathematics, mythology, and rice. Atlas Obscura. <https://www.atlasobscura.com/articles/indian-rice-art-kolam>
- [2]. Ferreira, R. (2023, September 12). Art and Math: Aesthetics of Calculations. DailyArt Magazine. <https://www.dailyartmagazine.com/art-and-math/>
- [3]. Fordham, M. (2021, December 14). Proof in history: The relationship between maths and art. ORIGO Education | Primary School Mathematics Resources and Programs. <https://www.origoeducation.com.au/blog/proof-in-history-the-intertwined-relationship-between-maths-and-art/>
- [4]. GOKHALE, V. (2004). ARCHITECTURAL HERITAGE AND SEISMIC DESIGN WITH REFERENCE TO INDIAN TEMPLE ARCHITECTURE. In 13th World Conference on Earthquake Engineering. [https://www.iitk.ac.in/nicee/wcee/article/13\\_2819.pdf](https://www.iitk.ac.in/nicee/wcee/article/13_2819.pdf)
- [5]. Mathematical Treasures - Albrecht Durer's Treatise on Mensuration | Mathematical Association of America. (n.d.). <https://maa.org/press/periodicals/convergence/mathematical-treasures-albrecht-durers-treatise-on-mensuration>
- [6]. Patil, U. (2022). A REVIEW STUDY ON ARCHITECTURE OF HINDU TEMPLE. ResearchGate. [https://www.researchgate.net/publication/362530501\\_A\\_REVIEW\\_STUDY\\_ON\\_ARCHITECTURE\\_OF\\_HINDU\\_TEMPLE](https://www.researchgate.net/publication/362530501_A_REVIEW_STUDY_ON_ARCHITECTURE_OF_HINDU_TEMPLE)
- [7]. Ricol, R. C. (n.d.). matematicasVisuales | Albert Durer and ellipses: cone sections. matematicasVisuales | Albert Durer and Ellipses: Cone Sections. <https://www.matematicasvisuales.com/english/html/history/durer/durerellipse.html>
- [8]. Shara, J. (2022). MATHEMATICS AND ART. ResearchGate. [https://www.researchgate.net/publication/358210455\\_MATHEMATICS\\_AND\\_ART](https://www.researchgate.net/publication/358210455_MATHEMATICS_AND_ART)
- [9]. The Invention of Infinity: Mathematics and Art in the Renaissance | Mathematical Association of America. (n.d.). <https://maa.org/press/maa-reviews/the-invention-of-infinity-mathematics-and-art-in-the-renaissance>
- [10]. Top 5 expressions of mathematics in art | Mathematics. (n.d.). <https://uwaterloo.ca/math/news/top-5-expressions-mathematics-art>