Mathematics in Art, from the Stone Age to Baroque

Artists have forever been trying to create the perfect paintings, which are absolutely mesmerising to any eye, whilst mathematicians have been searching for numbers which can explain this seemingly careless beauty. Alongside this, art and maths both represent universal languages which hold great meaning, and can be understood by most people in the same way across the globe. In this essay, I will move through time, starting with the Stone Age, and ending with the Baroque period, analysing the mathematical concepts used in each art movement, and how they develop over time.

Stone Age Art

Starting in the Stone Age, we see the development of early mathematical concepts, primarily geometry related, such as using symmetry and rotations. This was initially seen from 6000-4000 B.C., which is where I will date the beginning of our joining of maths and art.

Painted pottery showed complex designs with sophisticated symmetries, and the layout of buildings showed geometric design, including parallel lines, the use of right triangle ratios such as 3:4:5 and 5:12:13, and buildings using standardized length measure (Ubaid cubit of 0.72cm).

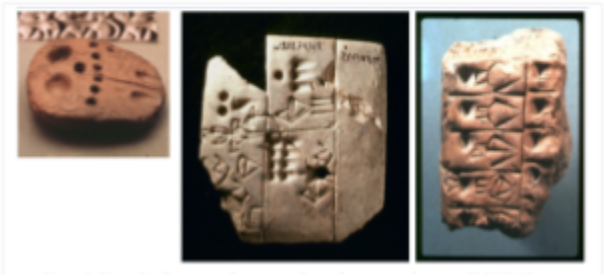

Figure 1

Egyptian Art

Figure 2

Progressing through time we move into the era of Egyptian art, which spans from approximately 3100-30 B.C. Maths is seen in their architecture in the careful construction of the pyramids, and their artwork of figures which represents the Egyptian Canon of Proportions. In figure 1, we see a painting from Tutankhamun's tomb, which displays King Tut standing before Hathor, the goddess of the

West, and behind him is Anubis, the embalmer god.
The Egyptian Canon of Proportions is seen here (and in many other similar paintings of the time) and was utilised to create art which presented communicated order, balance, and permanence, consistently representing human figures. These strict guidelines demonstrated hierarchy and social status, as we see here on Tutankhamun's tomb. The Egyptians used fists as a standard unit, and proportioned bodies using a head:body ratio, the standardisation emphasizing the idealised beauty and symmetry which was important at the time, rather than natural figures. The proportion of head:body was usually 1:4 or 1:5, as demonstrated in Figure 3. This shows that ancient Egyptian artists had an understanding of mathematics, and how utilising it in artwork could allow them to convey a message through crafting visuals with hidden numbers. The purpose of their artwork was less about realism, but more symbolic, as seen through the figures having two left feet, and as this essay proceeds we see how the usage of maths develops from this symbolism, to being used for accuracy of the human form.

The pyramids were constructed using an understanding of geometry, as the Egyptians used a range of geometric shapes, such as triangles and rectangles. Mathematical calculations were used to determine the dimensions of the pyramids, and a combination of astrology and mathematics were used for their precise positioning.

Figure 3

<u>Greek and Roman Art</u>

Moving into the next art movement is where the maths really starts to develop. The time of Greek and Roman art was between 850 B.C. and 476 A.D., and at around 300 B.C. is when Euclid first proposed the idea of the Golden Ratio. This was that a line segment could be divided into two parts, so that the ratio of the whole to the larger part is equal to the ratio of the larger part to the smaller. This segmentation was to divide a line at the 0.6160399… point, otherwise known as "dividing a line in the extreme and mean ratio", as described by Euclid in "Elements".

Figure 4

Where we see this ratio used in Greek and Roman art is firstly in architecture. A prime example of this is the Parthenon in Athens, which follows the proportions of the Golden Ratio. Whether this was intentional or not is unknown, but regardless it demonstrates how these proportions were found naturally to

Figure 5

humans, showing that numbers are nature. Figure 5 shows the Golden Rectangle and Spiral applied to the Parthenon. The Golden Rectangle perfectly fits the height and width of the building, displaying the use of maths by Greek architects to make buildings more visually appealing, despite the Parthenon being constructed from 447 to 438 B.C., and Euclid's discovery being written in about 300 B.C. We see this pattern used more clearly in the design work above the columns (Figure 6), where the Rectangle follows exactly, making this the most convincing evidence that the architects knew of this mathematics.

Figure 6

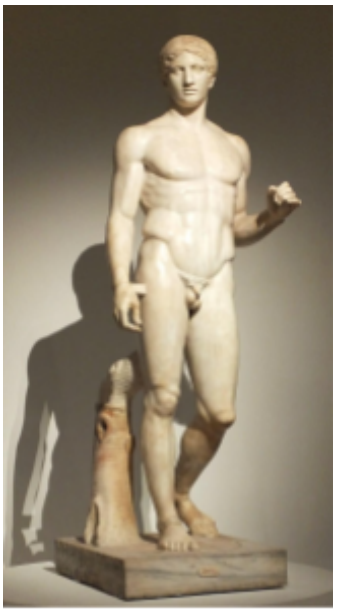

Figure 7

The Greek and Roman period also started to demonstrate the use of the Golden Ratio in artwork of the body, so the simple head:body ratios found in earlier times became more complex. Sculptures were popular in the Greek period, and sculptor Polykleitos' Doryphoros is a perfect display of the Golden Ratio, alongside a complex head:body ratio. This is that overall the head:body is 1:7, the legs and torso are the same height, which is three times that of the head. The width of the shoulders, the knees to the feet, and the height of the torso are twice the height of the head, the pelvis is ⅔ of the torso, and the thighs are ⅔ of the legs.

The way that Doryphoros represents the Golden Ratio is described by the Golden proportion characteristic, according to Gyorgy Doczi, The Power of Limits:Proportional Harmonies in Nature, Art and Architecture. Doczi explains that Doryphoros reflects a natural harmony, not only in figure, but also showing broader universal patterns that can be observed in nature. This overall gives meaning to artwork and mathematics, as great art speaks volumes on mathematics without any visible numbers.

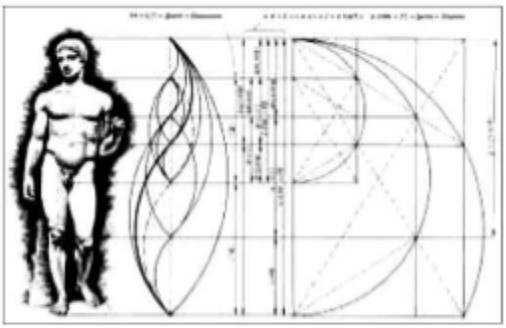

Figure 8

Chinese and Japanese Art

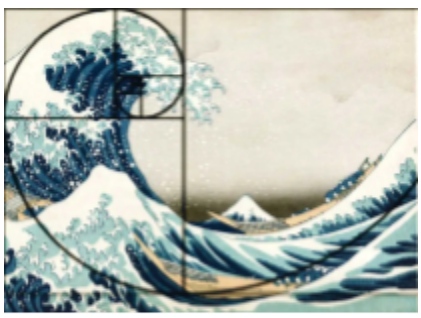

Figure 9

The era of Chinese and Japanese art spans from 653 B.C. to 1900 A.C., and it has two notable ideas which I would like to point out. Firstly, there is a clear use of symmetry in landscape painting and architecture/design, which links to the concept of feng shui. This incorporates ideas of spatial harmony through

arrangements, angles, and proportions, and calculating this is always mathematical. Maths brings harmony.
Secondly, I'd like to focus on a notable artwork, The Great Wave, Hokusai, c. 1831. This painting draws the viewer's eyes across the image, which is of no surprise, as once we look more closely, we see that this famous painting follows the Golden Spiral in its sweeping motion of the wave. This use of the Golden Spiral is meaningful, showing that there is structure within the forces of nature.

Renaissance Art

The Renaissance era spanned from the 14th to the 17th century, and it's where we see the resurgence of the Golden Ratio. This publicity can be owed to Italian Mathematician Luca Pacioli, author of "De Divina Proportione" (The Divine Proportion), published in 1509, with illustrations by Leonardo da Vinci. His work discussed the aesthetics in the properties of the ratio, and how it has a key role in constructing human proportions, so that this idea reemerged as a concept of divine and aesthetic importance. Da Vinci's work portrayed the Golden Ratio before his collaboration with Pacioli, which tells us that renaissance artists, alongside Da Vinci, such as Botticelli and Michaelangelo, were utilising the ratio before Pacioli's publication, but that his work made this more known and preserved. It is of no surprise that these artists knew of the Divine Proportions, as we previously discussed its usage in Greek times. This knowledge was preserved by scholars in the Islamic world, and it was in the European Renaissance where these ideas were rediscovered and expanded, as displayed by Pacioli.

A clear example of Da Vinci's use of mathematics is in his Vitruvian man (Figure 10). It's a depiction of a nude man with his arms and legs in positions in which the hands and feet touch the perimeters of both a circle and a square. This is from an idea proposed by Roman architect Vitruvius, who stated that if a man was flat on his back, his navel as the centre, with arms and legs outstretched, the hands and feet reach the circumference of a circle. Another proportion observed by Vitruvius is that the length of a human body's outstretched arms is the same as its height, thus the human figure can fit in a perfect square. Although Vitruvius made his discoveries before the Renaissance era, we see them used majorly during this movement, so I'll attest this mathematical discovery to both the Renaissance and Roman times.

Figure 10

Figure 11

Da Vinci also primarily used the Golden Ratio in his religious artworks, such as The Annunciation (Figure 11). The Ratio is seen in various ways, as shown in Figure 12, which describes the allusive nature of the image, with the figures and buildings placed in harmonious ways so that the human eye can appreciate its seemingly natural beauty. The use of the Golden Ratio is important for this time, especially in religious depictions, as it displays the value and power of religion, which society at the time appreciated.

Figure 12

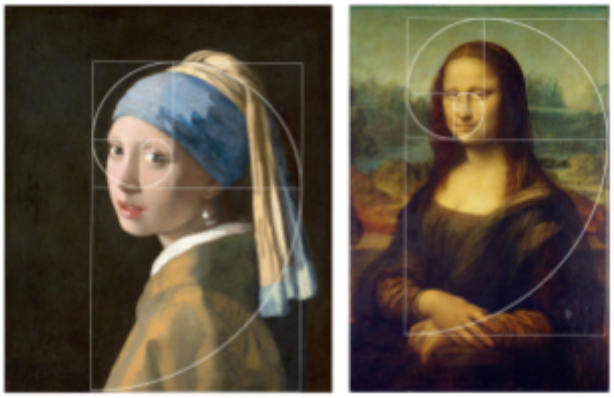

Figure 13

Further popular examples of the time include Leonardo da Vinci's Mona Lisa, and Johannes Vermeer's Girl With a Pearl Earring. When the Golden Spiral is applied to these works, the focus is on the eyes, which is part of what makes these paintings so timelessly captivating.

Baroque Art

Figure 14

The Baroque era was from around 1580 to 1750 A.D., slightly overlapping with the Renaissance.
This period was dramatic, using harsh angles, and a stark contrast between light and dark. The Golden Ratio is less evident, but we still see mathematical concepts, primarily the use of right angles, a simple yet effective method of creating bold art. My personal favourite example of this is Le Brun Charles' 'Daedalus and Icarus' (Figure 14). We see Icarus, illuminated, with his body making four lots of right angles, whilst his arm and leg are parallel. This gives the painting hidden structure through geometric organisation, and this method is common in many other Baroque paintings, particularly in those by Caravaggio, as seen in Figure 15.

The Baroque era represents the use of mathematics in artwork in a different, perhaps simpler way, which diversifies the usage of maths to really emphasize that it is everywhere.

Figure 15

Conclusion

In conclusion, art is maths, and maths is art. Mathematics and art, no matter how simple, have existed for an extremely long time, and different art movements throughout time demonstrate this, documenting our development of mathematical knowledge. It also most importantly tells us that numbers exist everywhere in various forms.
To finish, I'd like to note some of my favourite quotes for this topic. Firstly, "Without mathematics there is no art", Luca Pacioli, author of 'De Divina Proportione' which is, in essence, the point of this essay. These subjects are dependent on one another, despite commonly being separated due to ideas of the left and right brain. We should grow to see their undeniable link. Finally, a quote from René Descartes, loosely translated to 'With me, everything turns into mathematics', and more closely translated as 'but in my opinion, all things in nature occur mathematically'. This is what inspired my topic choice. Nature is mathematical, and artwork is nature.

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