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Role of Golden Ratio in Science, Arts and Mathematics

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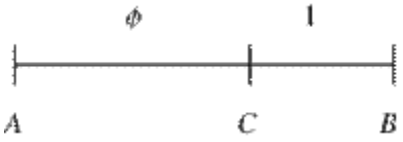
Abstract - The Golden Ratio, also known as Divine Proportion is a mathematical ratio with special properties and aesthetic significance. The concept of Golden Ratio has captivated the humanity for centuries. This paper seeks to represent a panoptic view of the miraculous golden proportion and its relation with the nature, Universe, Art, Design, Mathematics and Science. The mysterious secrets of Golden ratio concealed in human anatomy would also be explored. The paper would also discuss, how Fibonacci sequence has geometrical manifestation in the form of golden ratio.

Keywords – *Fibonacci sequence*

1. Introduction

The golden ratio otherwise known as the Divine Proportion is a mathematical ratio with special properties and aesthetic significance. The first definition of the golden ratio was shown by Euclid in Greece in B.C. third century. As per it, when a segment is divided into a shorter part and a longer part, and the ratio of the whole segment to the longer part is equal to that of the longer part to the shorter part, the segment is divided by the extreme and mean ratio



In other words, $AC/CB = AB/AC$ in the figure above. if AB has length 1 and
$AC = x$ where C divides AB in the golden ratio, then we can use simple algebra to find x.
$1/x = x/(1 - x)$ gives $x^2 + x - 1 = 0$ so $x = (\sqrt{5}-1)/2$.
Then the golden ratio is $1/x = (\sqrt{5} + 1)/2 = 1.6180339887498948482...$
This ratio is called Golden Ratio.

The golden ratio is believed to be the most aesthetically pleasing and harmonious means of design. It exists everywhere around us. They include visual designs such as paintings and sculptures, literature, music, even the shifts of the economy. An enormous number of things in the universe are engineered around the ratio , ranging from the human body to the ark of the covenant to snail shells to the orbits of the planets.

Golden Ratio is not confined just to mathematicians. Biologists, artists, musicians, historians, architects, psychologists, and even mystics have pondered and debated the basis of its ubiquity and appeal.

2. Role in Mathematics

This Ratio has inspired thinkers of all disciplines like no other number in the history of mathematics. The phenomenon of the Golden Ratio settled down for several centuries after the Greeks, only to be revitalized during the European Renaissance by Italian mathematician Luca Pacioli and his three-volume treatise entitled *Divina Proportione,* which contains a detailed study of the Golden Ratio and polyhedral solids. In fact, Pacioli is most likely the cause of today's widespread fascination with phi. In his work, Pacioli replaced the rather intimidating names for the now-famous Ratio (names like"extreme and mean ratio" or "proportion having a mean and two extremes"), referring to it instead as the Divine Proportion.

With the development of algebra by the Arabs one might expect to find the quadratic equation (or a related one) to that which we have given above.

3. Role in Anatomy

Man's heart is beaten uniformly (about 60 impacts in one minute in the rest state). The heart as the cylinder piston compresses, and then pushes out the blood and drives it on the body. The pressure of the blood changes during the cardiac performance. It reaches of the greatest value in the left heart ventricle at the moment of its compression

(systole). In the arteries during the heart ventricular systole the blood pressure reaches the maximum value, equal to 115−125 mm of the mercury column. At the moment of the cardiac muscle debilitation (diastole) the pressure decreases until 70 −80 mm of the mercury column. The ratio of the maximum (systolic) pressure t o the minimum (diastolic) pressure is equal, on the average, to 1.6, that is, is close to the golden proportion.

4. Role in Architecture and Design

A geometrical analysis of the Great Mosque of Kairouan, built by Uqba ibn Nafi c. 670 A.D., reveals a consistent application of the golden ratio throughout the design. The analysis was done by Boussora and Mazouz who said that the golden ratio was found in the overall proportion of the plan and in the dimensioning of the prayer space, the court, and the minaret. The Stuppa of Borobudur in Java, Indonesia, the largest known Buddhist stupa was built in eighth to ninth century AD, has the dimension of the square base related to the diameter of the largest circular terrace as 1.618:1.

The Golden Section was used extensively by Leonardo Da Vinci. All the key dimensions of the room and the table in Da Vinci's "*The Last Supper*" were based on the Golden Section, which was known in the Renaissance period as The Divine Proportion.Credit cards are also in the shape of a Golden Rectangle. Standard sized credit cards are 54mm by 86mm, creating a ratio of 1.5926, which is approximately 1.6.

5. Fibonacci Sequence

We have discussed about the golden ratio starting with Euclid's geometric idea, but there is another algebraic way to approach the ratio. There is a sequence that leads to obtain the golden ratio. The sequence is called Fibonacci sequence. Fibonacci is the name of a mathematician. Leonardo Fibonacci was born in Italy.
He gave a problem related to the population growth rates of rabbits, which lead to golden ratio.

As per the problem, Each pair of rabbits became productive the month after the birth. Therefore, the number of pairs in each month is always the sum of the number of pairs plus the number of productive pairs in the last month. The number of the productive ones is equal to that of pairs one month ago. Therefore, the number of the pairs of each month is always the sum of that of one month ago and two months ago. Then, the number of pairs is represented by this recurrence formula.

$$F_{n+1} = F_n + F_{n-1}$$

In the first month, the number of pairs of rabbits is one. In the second month, the number of pairs reminds one. Then, in the third month, the first pair breeds another pair, and the number of pairs becomes two. In the next month, it becomes three. In the fifth month, it becomes five. It will be easier to find the way the population increases if we make a chart of the number of pairs of each month

month	1	2	3	4	5	6	7	8	9
pair	1	1	2	3	5	8	13	21	34
productive	0	1	1	2	3	5	8	13	21

The sequence generated by this recurrence formula was named the Fibonacci Sequence and it shows a surprising relationship to the golden ratio. The fibonacci sequence is made up of numbers that are all the addition of the previous two numbers in the sequence. The sequence starts with 0 and 1 and continues with 1, 2, 3, 5, 8, 13, 21, 34 and continues in this fashion. The sequence is infinite as one can continue adding the previous numbers forever.

When we take any two adjacent numbers in the fibonacci sequence and use them as the measurements for the sides of rectangles we can see the golden ratio emerge again. Any rectangle constructed from two adjacent Fibonacci numbers will have the height to width ratio of 1:1.618. This rectangle is called the golden rectangle, because of its closed relation with Golden Ratio.

The arrangement of the seeds in sunflowers has an apparent and exact relationship with the golden ratio. In the heads of sunflowers, there are two groups of seeds. One group of seeds grows in spirals clockwise, and the other grows in spirals counter-clockwise. The number of each spirals tends to be the Fibonacci number

6. Conclusion

Natural and artificial design always contains certain elements that provide the aesthetic attributes of the individual structure or item. It indicates a harmony in design and consistency within that harmony, and structures in patterns or how the individual aesthetic elements fit into the core design. It is a beautiful mathematical ,biological, architectural and artistic construct that is found everywhere we look.

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