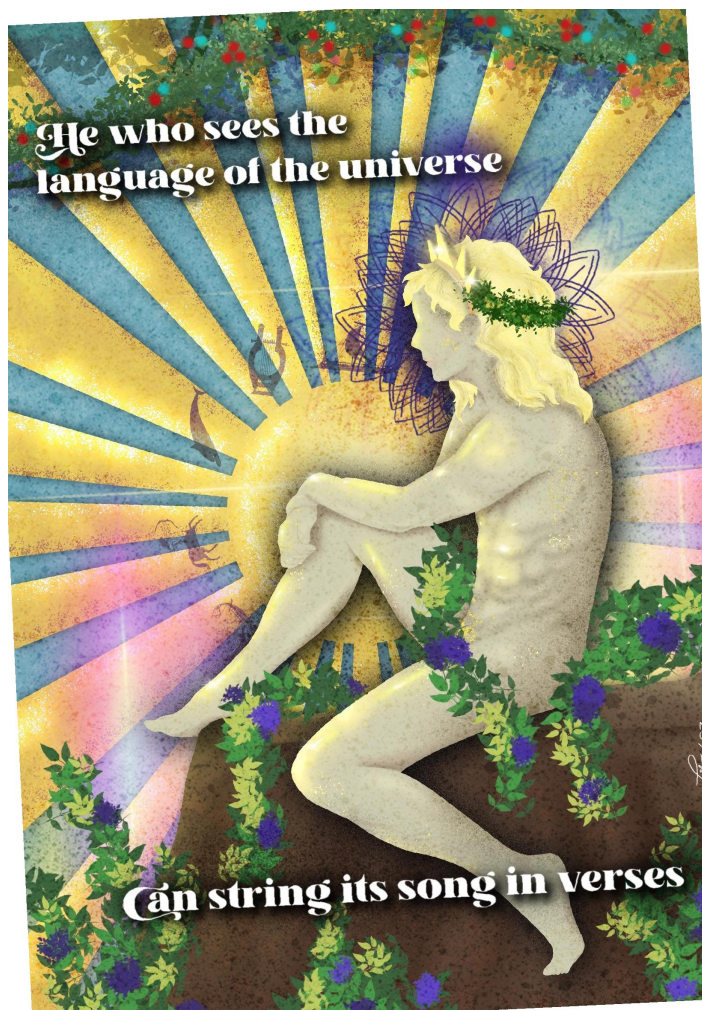




He who sees the
language of the universe

Can string its song in verses

Introduction

A modern scientist will tell you that the language of the universe can be found in mathematics. Every process in nature can be compiled into formulae and understood through numbers. If Physics shows the laws of cosmos, Chemistry the composition of cosmic creations, and Biology the rules that these creations follow, then they all can be assimilated under the umbrella that is Mathematics. Mankind's progress is written in the development of mathematical studies. The growth of our civilization lies in the hands of mathematics, and those who water that plant of numerals with newer approaches everyday.

In analysing the universe and our world with this modern scientific outlook, we tend to forget to look back. Even when we do, we don't ponder far enough. Our understanding of science comes from the rudimentary sense of modern development. Nothing beyond a few centuries interests us when we ask, "What has mankind achieved as a species that can read and experiment?" This partial look back creates a void in our understanding of human history: we see ourselves start as savage beings drawing animals on cave walls, then building cities in the name of invisible gods, to become a species that rapidly furthered its knowledge through hypotheses and research. Human history is not such a simplistic territory: the stage for science was set at the same time when cities built temples larger than themselves in the name of invisible gods.

Here, I come back to mathematics. And with the numbers I bring the cult that changed mathematics as we know: Pythagoreanism.

Pythagoras is quite a familiar name. The theorem in his name is taught to students across the world in schools. When we calculate how long the hypotenuse of a right angle triangle would be, we do not exactly think of a cult, or music and poetry. And when we discuss cults, mathematical or scientific progress isn't the first idea that occurs. Pythagoreans smother all those notions. Instead, they offer a view of the universe that is truly well ahead of their time, and has since been forgotten.

Academia is quick to divide mathematics, music, poetry and art into their own domains, albeit admitting there is some connection between them. But it would be grave injustice to read a poem or study a song without giving thought to the math behind it. Pythagoreans accepted this relationship, and they rightly bestowed the prowess of these elements on one god: Apollo.



theorem until Pythagoras has much to do with the implications of irrational numbers, more on which has been discussed later. Through contacts with India via Arab, Pythagoras and his followers became masters of mathematics. They observed nature to draw conclusions. They conducted experiments to understand the why's of nature, instead of merely seeing them as vague messages from the divine. They proposed that the sun was a ball of fire, earth a sphere, and the stars other balls of fire, but too distant to make their heat feel like the sun. The sun's precise movement across the sky and the routine of its rise and fall throughout the year created a sense of stability. And this stability, according to Pythagoreans, comes from the fact that mathematics itself is a stable subject, and therefore it must be the language of the universe.

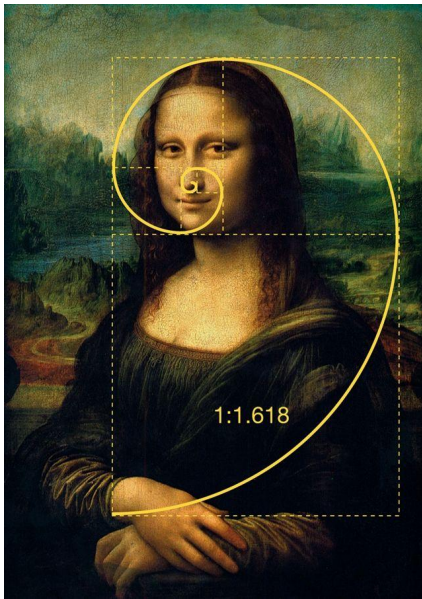
According to Pythagoreans, the world is composed of opposites: heat/cold, dry/wet, and so on. The key to understanding these opposites lies in mathematics. Their motto was "All is number" or "God is number". For instance, to them the even numbers represented the infinite, as when they are halved again and again, the final result is always 1. The even numbers were male. The odd numbers represented the finite, because they were not divisible as even numbers, and female. The number 5 signified marriage, as the sum of 2 and 3. It has strong influence of the gender dynamics of the time.

Thus, they derived that the universe had originated from Chaos (καος), a concept which Ovid later propagates, and the earth and other heavenly bodies were arranged in an order only when complex mathematical relations came to play. Instead of Gaia in the myths, Chaos was followed by mathematical order. This order exhibits itself in everything around us, because they all create one unit: The Universe. Pythagoreans gave immense importance to the number 1. They saw 1 as the generator: the number from which all other numbers arise.

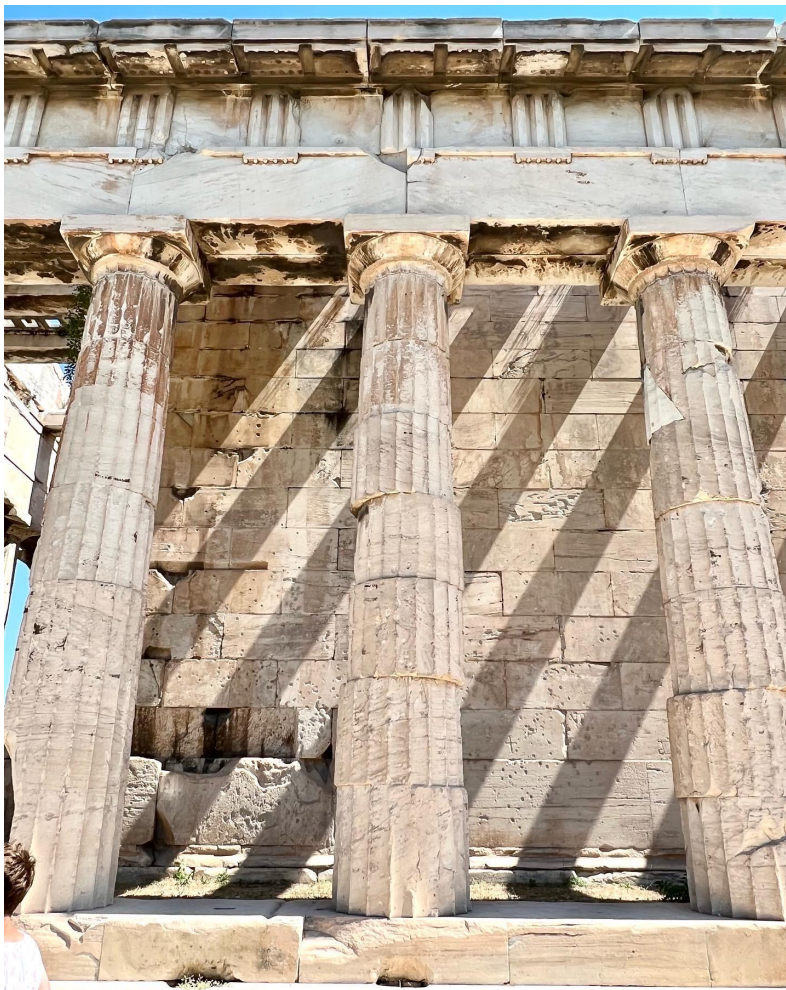
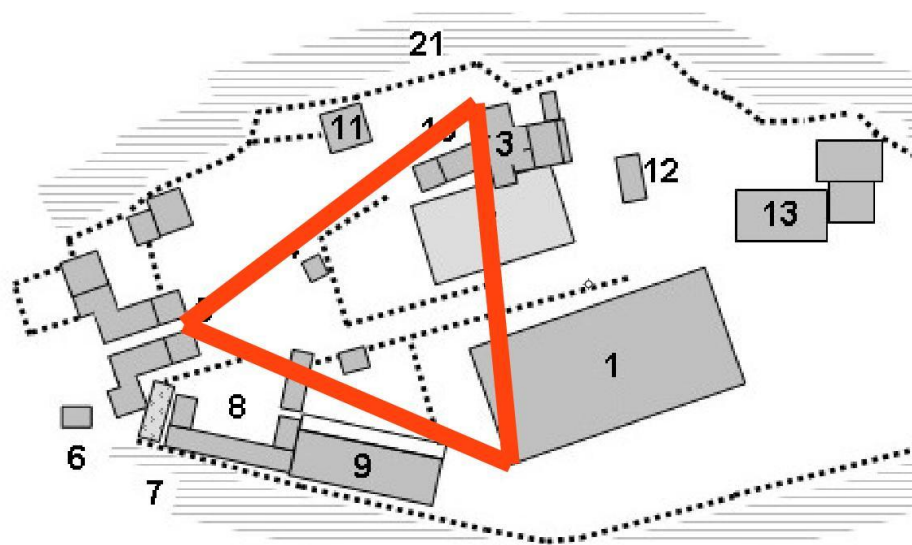
The math of art

To better understand the mathematics of the universe, they attached the concept of music and art to it. Music and poetry, which were often performed as musical poetry in Classical Greece, had an identifiable pattern of beats and rhythm. They believed that music has the same effect as medicine on the human body, a theory proven true in some parts today. The Ancient Greeks saw poetry and music as abstract and divinely inspired. Therefore the perfection in music through mathematics gave them a bridge between the divine and the mundane. This principle became highly important, as it was seen as a means to imitate and reach the gods themselves. The precision of mathematics in nature was to be imitated in music and art so as to make them perfect, and this principle plays into the excellent Greek sculptures that we see today. The





This led Ancient Greeks to build monuments of precise mathematical order. Perhaps the best example is the Parthenon in Athens: an example of the fine architectural achievement of the Greeks. Each pillar of the Parthenon is designed using optical refinement to look organic by thickening them at the base, while also ensuring they were strong enough to hold the ceiling in place. The façade of the temple used the Golden Ratio (1:1.618). The Caryatid is yet another fine example.



(Below) A close-up of the pillars of Parthenon, Athens, built: 447 and 432 BC. The shape of the column shafts, and their slight tilt from the vertical, are said to correct optical distortions so that the building appears to be perfectly regular. The columns taper towards the top, but also swell slightly part of the way up, to avoid an impression of narrowing at the centre.

Pythagoreans were the first to experiment with strings to create music. AC Grayling writes,

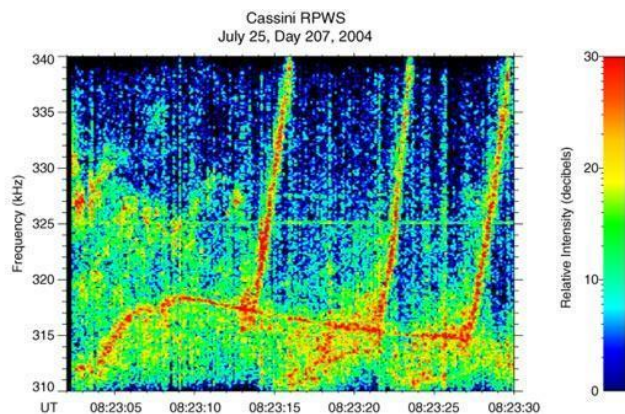
"The mathematician Aristoxenos said that Pythagoras was the first to take the study of arithmetic beyond the practical needs of commerce...the pitch of a musical note depends on the length of a string whose vibrations produce the note, and that simple numerical ratios explain the consonant intervals of the scale: 2:1 octave, 3:2 perfect fifth, 4:3 perfect fourth, and so on. To understand this, think of two guitar strings of equal length, tension and thickness. If they are both plucked together they sound the same. If different lengths of each are plucked, they sometimes sound dissonant and sometimes consonant. This latter observation underlies measurement of consonant intervals – an interval being the distance between two notes, and a consonant interval being one in which the two notes sound good together. Experiment will show that if you have two lengths of string of equal length, tension and thickness, plucking one while simultaneously plucking exactly half the length of the other will yield a consonance – this is the octave."

Music and poetry both employ meter: the key to make them sound pleasant to the ears.

Astronomical developments of the Pythagoreans

This mathematics of music, they took to the planets, proposing the idea of *harmonia* or harmony. For the world to exist there needs to be order, and harmony is the mathematical display of this order. In fact, the idea of entropy heavily depends on the existence of ordered law, and therefore both creation and destruction are calculable ideas. According to them, planets are arranged in a concentric series of paths, and every planet emits its own music based on its size, position and so on. Today, we know this is true to some extent thanks to the various space probes we have sent out to outer space: "In 2022, people on Earth were able to hear the planetary sounds of Mars thanks to two microphones installed on board NASA's Perseverance rover...The planetary sounds we hear, are wavelike vibrations of air molecules occurring within the range of frequencies to which our ears are sensitive, according to the BBC ...it's possible to process any other kind of wave or oscillation electronically, scaling it to audible frequencies and then converting it into a sound wave...The process of turning

non-acoustic data into audible sounds — called sonification — can have benefits for astronomers involved in analysing the data, according to Scientific American."



*Saturn's radio emissions, which have changes in frequency (127Kb Wave Sound).*¹

Pythagoreans suggested that the moon has no light of its own, but merely reflects the light of the sun. They held the opinion that beyond the planetary system we know, there are other planetary systems as well, with their own suns. They also proposed the revolutionary idea of reincarnation: Metempsychosis. This was possibly an influence of Indo-Greek exchange of ideas as well, but for Europe this was a first. Pythagoras deeply supported the idea that good deeds can help one transcend the cycle of rebirths to reach the divine, something the Vedas and Buddhist philosophies also support.

The intersection of the divine and the mundane

The work of the Pythagoreans in understanding the world through mathematics closely linked the belief system around Apollo. I had previously mentioned that Apollo is the god of prophecies in the Greek pantheon: he alone has the power to foresee events in the future that are bound to happen. Even in this, mathematics plays a vital role. Astronomers today can make complex calculations to understand the age of the universe, how long the sun will last, and predict cosmic events at a time scale that we can hardly comprehend. For instance, by studying the weather and climate of a place in the past, scientists can build a mathematical model that would allow them to predict the weather in the upcoming days. Such formulae are also used to predict how the sun will age and when it becomes a Red Star, how far it will expand. Pythagoreans recognised the possibility of building such numerical models, although they themselves could not make astronomical predictions with the accuracy we have now. Thus, it would not be a mistake to say that mathematics is the key to seeing the future,

¹ Image from NASA



In this, Pythagoreans recognised the mathematics of war. From the use of weaponry to formation of armies, called *strategia*, the use of mathematics can help a warrior win even with limited resources. The accuracy of an arrow depends on the calculations that go into shooting it, and Apollo is a master of both. Modern weapons use mathematical equations to shoot missiles, which again depend on satellites built through math. Even though guns have replaced arrows, Apollo's influence on warfare remains.

Apollo is also said to have shot arrows of plague towards the enemy, and use his skills in medicine to heal his worshippers. Modern medicine is heavily dependent on mathematical calculations, and this must have held true for the Pythagoreans as well. They could observe the calculated precision required to concoct a medicine: how the excess or lacking of an ingredient could change a medicine from potent to poisonous. They could also have seen the relation between weather and disease. Thus a proper calculation of weather could tell them if they would be plagued by disease or spared. The plague would also depend on location, and Pythagoreans were heavily engaged in calculating the earth's size and where various states were located on the surface of the earth. The relation between music and health is also another proof of how well they understood the importance of math in everyday life. Patients of dementia are often told to listen to music to help their nerve cells, and the mathematical patterns of a song help regulate the body's blood flow. Pythagoras is attributed to have first discovered the link between music and wellness of mind.

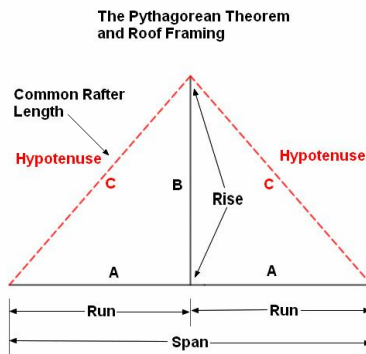
According to scholars: "One day, (Pythagoras) was passing by a blacksmith, and suddenly, he noticed the sound of a hammer and found it to be musical. He rushed inside the shop and started beating hammers of different sizes on the table. He observed that the tune played by the hammer was directly proportional to the size of the hammer, hence he proved that music was mathematical."

The Pythagoras Theorem

$$a^2 + b^2 = c^2$$

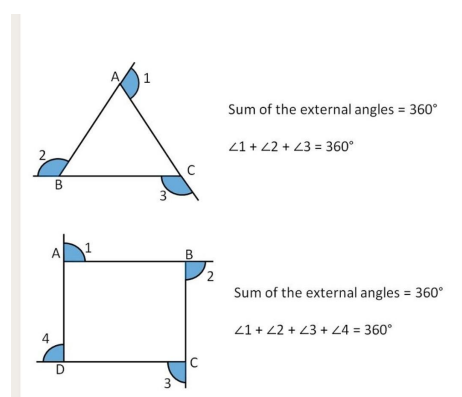
The Pythagoras theorem has multifaceted uses, which the Pythagoreans perfected. The precision of Greek architecture has been mentioned before, so it is no surprise that the Pythagoras theorem is used even today by architects and engineers. Here too we find Apollo, who alongside Poseidon built the impregnable walls of Troy. The Pythagoreans who grew up listening to the myth of Troy saw in those walls the mathematical tricks of building strong structures, and Apollo as the builder only reinforced their faith in the god as the greatest mathematician. As the myth goes,

Apollo also predicted that the wall will only fall on the third attempt, as would the city of Troy. A prediction of this sort can be made by a modern engineer as well, thanks to numerical equations. Plato is believed to have heavily derived from Pythagoras' study of mathematical principles, and used it to derive logic and reasoning in his own works.



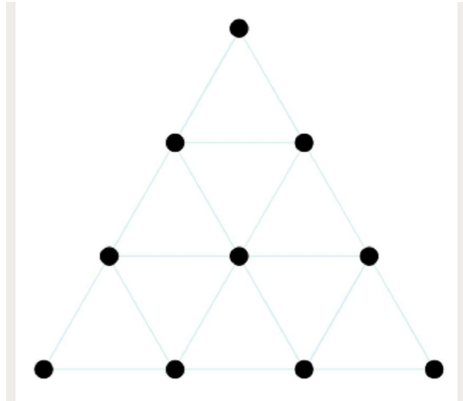
Geometry provided architects with the tools necessary for proper design and construction (Leonardis, 2016). The temple construction was based on the use of such ratios as 2:3 and 4:9. Moving from more minor parts to more significant amounts was the fundamental strategy based on the essence of symmetry. This design led to the construction of buildings characterized by such concepts as symmetry and harmony³

Pythagoreans did not remain confined to right angled triangles. They discovered that the "sum of all angles of a triangle is equal to two right angles" and that "polygon with n sides is equal to $(2n-4)$ right angles and the sum of its exterior angles is equal to four right angles....They were also able to compute the solution of equations like $a(a-x)=x^2$ with the help of geometry."



³ IvyPanda. (2023, July 5). Mathematics in Ancient Greek Architecture.

They also pondered over the geometry of Tectactys: representing the number 10. It closely tied to the representation of numbers via dots. The Tectactys is perfect in their opinion because it represents the four Classical elements: fire, water, earth, and air.



As Grayling writes: "Pythagoreans thought that ten is the natural basis of counting, and gave it a mystical significance. There is of course an infinity of 'triangular numbers' – three is represented as the triangle of two dots with one dot above it; six is represented as a triangle of dots arranged '3–2–1'; ten we have seen, fifteen is '5–4–3–2–1', and so on."



4

Conclusion

It is rather easy to dismiss Pythagoreanism as a cult that coincidentally got things right. They faced quite some barriers in their studies. For instance, they are attributed with discovering irrational numbers, but the experience stumped them so much that the one man who revealed this finding to the other members was punished by being drowned to death. Some scholars believe that the irrational numbers caused Mesopotamians to give up studying the Pythagoras theorem. The Pythagoreans used a simple explanation: if the horizontal side is 1 inch (or 1 metre, yard, and so on), then the diagonal would be the root of 2. But the root of 2 is not a whole number, and neither is it the familiar fractional number. This shocked them, yet, they recorded the discovery and today irrational numbers are as indispensable as rational numbers. And we know that the rule applied to musical strings does not adhere to planetary positions. But for us to reach these conclusions, as well as make impressive progress

⁴ Grayling; *History of Philosophy*

with the aid of math, the contributions of Pythagoreans must be admitted. Their understanding of the universe can be simply assimilated in one figure: Apollo. And when one sees the connections that thread together the god's powers, one can see the dedication and precision of the people who worshipped him.

Mankind has often been set back in their progress by socio-political factors. But the loss of Pythagoras' works and those written under him is a grave blow to our progress that is worth acknowledging. A mathematician who undertakes the difficult task of finding the meaning of the universe must start with Pythagoras and his school. Because this is where our collective journey as a species to find reason against the vast cosmic background began and took a prolific shape. It set the stage upon which our society stands today.