

Path 3. Numbers and Numbering

How and why an ancient civilizations did develop counting skills and numeral systems? Why and when the Hindu–Arabic numeral system did come to Europe? Why, even though we use the same number system, in some languages numbers are written differently?

The need for numbering – ordering certain phenomena according to their quantity – as well as for writing down numbers and simple calculations, appeared quite early in the development of the humankind. At first these were obviously very simple inscriptions, only referring to prime numbers (as we tend to name them now). They were made by means of long incisions in certain materials. The oldest finding of the kind is the so-called *Ishango bone*, discovered near the Nile River headwaters, dated 25,000 – 20,000 BC. Initially, people developed their counting and number writing skills in order to do simple calculations, critical for their life: hunters were planning their hunt, women were counting days until their next period, chieftains estimated how numerous their enemies were. However, as the various forms of human activity, such as farming, constructing and trade, developed it became necessary to utilise more complex mathematic systems, allowing for more complicated processes and measurements.

Historic development of mathematics is one of the first examples in the history of the importance and benefits of transferring knowledge between cultures, most of all those inhabiting Europe and Asia. Together with conquests, migrations and commercial exchange spread the knowledge as well as achievements of civilisation. The oldest numeric and mathematical systems were developed in Mesopotamia (since around 3,500 BC) and Egypt (since around 3,200 BC). The findings of Mesopotamian and Egyptian mathematicians were used by ancient Greek philosophers, who are regarded one of the creators of modern European mathematics. The second pillar for the development of this science were Arabic mathematical systems, constructed on the basis of mathematical problems and techniques coming from India (since around 2,000 BC). The Indian achievements was also used in mathematics that developed in China (since around 2,600 BC). For geographical reasons only mathematics in South America developed in relative isolation.

The ancient Babylonians wrote down a multiplication table by means of cuneiform script as early as around 2,500 BC. They could add, subtract and divide. They knew fractions and percentage. Around 1,750 BC they also developed sexagesimal numeral system, which we can still trace in today's mathematics. It is the reason why an hour is divided into 60 minutes, a minute – into 60 seconds, and a round angle (a circle) has 360 degrees ($60 \cdot 6$). Interestingly, the Mesopotamians did not know zero.

Ancient Egyptians were the first to start mathematical calculations related to the calendar, they began their research as early as 4,800 BC. The calendar as we know it, with 365 days and divided into 12 months, was developed by them around 4,200 BC. Egyptians had a very practical approach to mathematics and they developed mostly these fields which allowed them to do measurements and geometrical calculations for the purposes of constructing massive edifices as well as watering systems. Therefore they reached high level of expertise in calculating the surface and volume of different figures: triangles, rectangles, trapeziums, cuboids, pyramids, and cylinders. Although Egyptians wrote down their complicated calculations by means of hieroglyphs, they did not know zero, either.

In India, on the other hand, numbers and calculations were mostly used for observing the sky, while practical aspects of mathematics were of secondary importance. Calculations made by the Indians reached high level of complexity and were related to a wide range of mathematical notions and problems. Due to Indian mathematicians the youngest numerical digit of the decimal system was discovered at last – zero. It was from India that Arabian mathematicians took the decimal numeral system, which we now call Arabic numerals, and which next (already in the Middle Ages) came to Europe, from where the numerals spread all over the world. Such was the evolution of Indian numbers, later called Arabic, which in their Europeanised form (written in Latin alphabet) are known to us as: 0,1,2,3,4,5,6,7,8,9. In Arabic and European countries the same numerical system is used, but is written in different alphabets. In Arabic, the same numbers will look very different: ١, ٢, ٣, ٤, ٥, ٦, ٧, ٨, ٩.

Numbers also owe a lot to ancient Greek philosophers. It was the Pythagoreans that around 540 BC concluded that “number is the substance of all things”. They had the conviction that with the use of numbers, cycles, harmony, and proportions the whole world could be described. It is therefore numbers, perceived as a measure of all the observable phenomena, that allowed the Greek to perform their research of natural phenomena and processes. Thus a cypher or a number, as the Greek understood it, was no longer just a utilitarian symbol employed for the purposes of writing down calculations, but a measure and a specific designation of the reality and the relationships governing it. The Greek numeral system was based on representing the numbers by means of letters of the alphabet. This is important since Greek letters for numbers are also used in modern mathematics (α' , β' , γ' , δ' , ϵ' , ζ' , η' , θ' , etc.) Also the mathematical discoveries of Thales of Miletus (c. 624 – c. 546 BC), Pythagoras (c. 582 – c. 507 BC), Euclid (c. 365 – c. 300 BC), Archimedes (c. 287 – c. 212 BC) and many other Greek thinkers formed the basis for contemporary sciences.

In the history of Europe there were times when numbers and mathematics were perceived as a threat for religion or politics. In the first half of the 6th century emperor Justinian I issued a code of laws with a paragraph entitled “On Sorcerers and Mathematicians”. It banned Mathematics as harmful and deserving condemnation. The fall of the Roman Empire together with the Greek-Roman culture caused a drastic decline in mathematics. For people in the early Middle Ages it was sufficient to add, subtract, multiply, and divide, using Roman numbers (I, II, III, IV, V, VI, VII, VIII, IX, X, XX, XXX, XL, L, etc.) as well as to use the basic geometry. At the same time Islamic and Persian countries were at the peak of their cultural and scientific development, drawing extensively on the works of ancient Greece and India. It was the Arabic and Persian mathematicians that between 8th and 15th century developed on a grand scale the algebraic, arithmetic, geometric, and trigonometric ideas. It was only in the 12th century that due to more intensive contacts with the Arab world (once again – due to inter-cultural exchange), the writings of Arabic mathematicians started to appear in Europe, together with Arabic translations of ancient scholars’ works.

Crucial for the development of the modern European number system was year 1202 when Leonardo of Pisa, commonly called Fibonacci, published his book *Liber Abaci*. Basing on the knowledge he gained during his journeys to Arab countries, Fibonacci presented a way to calculate utilising Indian numerals, at the time used by the Arabs. Since that moment we can talk about development of a number system in Europe that we at present use every day. What is interesting, it was not until the 15th and 16th centuries that the symbols we know today: “+”, “-”, “=” started to be used in operations. In Renaissance Europeans became once again interested in developing mathematics as an independent field of knowledge. In the later ages such scientists as: René Descartes, Pierre de Fermat, Isaak Newton, Gottfried Wilhelm Leibniz, Blaise Pascal, Carl Friedrich Gauß conducted research and made inventions that formed the mathematical and scientific bases of the industrial revolution of the 19th century and the technological revolution of the 20th century.

We do not always realise the critical importance of numbers and mathematics for the functioning of a human being and the development of our civilisation. And yet they are utilised in almost any sphere of human activity, from electronics, mechanics, economy, architecture, optics, medicine (and many, many others), to the most down-to-earth activities, such as shopping, calculating the credit, or assigning car registration numbers. Interestingly, although throughout the centuries people developed a few dozen different numeral systems, with thousands of characters and referring to various methods of notation, the inventions of computer and the basic digital technology, defining the today’s world, are based on the two simplest numeral systems: the unary and the binary one.

The unary numeral system, in which to represent numbers a symbol representing “1” is only used, with subsequent numbers created by repeating the symbol as many times as the value of the number requires, was used by Alan Turing for creation of an abstract model of computer able to perform algorithms. The Turing machine became the point of departure for works on calculating machines which we today call computers. The binary numeral system, on the other hand, where number 2 is the basis and numbers are written with use of 0 and 1 symbols, is commonly used in IT and digital electronics.

Finally, it is worth mentioning that, both in the past and today, people have been trying to attach symbolic, or even magical, significance to numbers. Depending on the religious, cultural, or language environment the particular cyphers and numbers were given various symbolic meanings.

One (1) is regarded a perfect number, the first odd number, used most of all to refer to God. It symbolises uniqueness and autonomy. In Chinese numerology the number is referred to creative power as the basis of everything that exists, as well as to *ego* and the beginning and source of important stages of a human life.

Two (2) refers to dualism (e.g. of soul and body, good and evil). It has been usually regarded an ominous number. On the other hand it is related to the notion of a couple, a man and a wife, a sacred notion as such. In Chinese tradition the same number refers to harmonious interaction between *yin* and *yang*. Two is thus a symbol of balance, order, the ability to bring together the opposites, moderation.

Three (3) is a symbolic number for many cultures (the Three Magi of Bethlehem, God in three persons, the Three Graces, the Three Parcae, the Three Musketeers, etc.) It usually brings positive associations. In Chinese numerology it means intuition, magic, creative powers. It also symbolises time as consisting of past, presence and the future.

Four (4) is considered a holy number in numerous cultures. In Greece it used to be associated with the four corners of the world and the four seasons. Christianity connected it to the Four Horsemen of the Apocalypse, the four Gospels. In the popular culture a four-leaf clover brings luck. In China the number stands for stability and order, peace and reliability. In the Japanese culture the meaning is contrary – four brings bad luck, it is associated with death. Many buildings do not have the fourth floor, while in hotels a room with this number is never rented.

Five (5) is associated with the number of fingers, the senses, the number of books in the Old Testament, it is regarded a lucky number. In Chinese culture it is associated with travellers, explorers and inventors. It symbolises searching, movement, and change.

Six (6) is a lucky number, a symbol of peace and happiness associated with the number of days in which the world was created and the six-pointed Star of David. In China this is a symbol of balance, love and truth, as well as inspiration that one's mind gets when relaxed and in a state of inner harmony.

Seven (7) is one of the most magical and holy numbers. It appears many times in the Old and New Testament. It is most strongly associated with the symbolic meaning of creation of the world and the Apocalypse. Thus it is associated with the notions of wholeness, entirety, bringing something to an end. The number also has a symbolic meaning in Islam which requires the believers to make seven circumambulations of Kaaba in Mecca, shouting *Allah akbar* (God is the greatest) seven times. Islam also teaches there are seven heavens, seven hells, seven big sins and seven aspects of Quran. In China, on the other hand, seven is associated with imagination, a conscious thought and concentration.

Eight (8) brings associations with perfection and infinity by its shape alone. Christianity attaches much significance to it, associating the number to the beatitudes of Christ. In Chinese numerology the meaning of number eight is associated with success. It symbolises determination and persistency in reaching one's goals.

Nine (9) is associated with good luck. The Chinese relate it to intelligence, invention, creativity and reaching one's full potentials in a given field. The number symbolises the fact that each of us has a potential to change the world around us for better.

Other numbers that generally bring certain association are of course "13" as a symbol of bad luck, "666" as a symbol of devil or evil.

The invention of numbers and the development of the numbering skills, from the simplest calculations to the most complex models and theories, was the *sine qua non* condition of all the civilizational developments. Some people believe that numbers (calculated on the basis of the date of birth) determine the whole human life. Some people take key decisions based on the indications they find in numerology.

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