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On the Four Hundred Anniversary of Blaise Pascal's Birth

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ABSTRACT

He was a genius of science, mathematician, physicist, philosopher, father of digital computing, probability, experimental physics, hydraulics, integral and differential calculus, projective geometry, genius of universal literature. Pascal lived in the 17th century, which was a century of profound struggle between intelligence and repression, where Modern Philosophy was inaugurated. This period was marked by the solidification of the concept of subjectivity, with the emergence of modern epistemology and the rupture with the Scholastic doctrine. With his devotion to the activities of thought, involving science, philosophy, religion and the arts, Pascal lived centuries ahead of his time. Pascal was able to systematize many fields of knowledge. He was a philosopher, writer, mathematician and physicist. Undoubtedly one of the greatest figures of the seventeenth century and one of the most enigmatic and creative personalities in history.

BRIEF BIOGRAPHY OF BLAISE PASCAL

Blaise Pascal[(1)] was born on June 19, 1623. After his mother's death, he was personally educated by his father, Etienne Pascal, a man also dedicated to culture and science. Around the age of eleven, in 1634, without consulting the works of Euclid, for which his father considered him still too young, he reinvented the most important mathematical work in the West: the book The Elements, by the Greek Euclid. This work is the most reproduced and studied in the history of the western world. Pascal reconstructed the book The Elements, enunciating the fundamental theorems of geometry and their demonstration, in the same order established by Euclid. At the age of sixteen, in 1640, he published the work Essai sur les coniques, formulating one of the basic theorems of Projective Geometry, known since then as Pascal's Theorem. At the age of nineteen, in 1643, with the aim of helping his father, he designed the first calculator, patented under the name of La Pascaline. At the age of twenty-one, in 1645, he built and sold close to forty examples of his calculating machine, which was considered the most extraordinary device of the time, the ancient precursor of a generation of machines that would lead to modern computers. More than a century would pass, however, before calculating machines were built and spread around the world. Pascal's calculator, the pioneer of a long generation of mathematical machines, is housed at the Paris Conservatory of Arts and Measurements. Pascal was also the first to consider using binary language as the basis for programming calculations and processing logical operations, making him one of the great precursors of Artificial Intelligence. These Pascal[(2)] devices linked his name to the history of computing. In his honor, his name was also attributed to an important computer programming language: the Pascal language. At the age of twenty-four, in 1648, Pascal turned to physics, researching fluid mechanics and clarifying the concepts of pressure and vacuum. He discovered that the pressure acts perpendicularly to the surfaces that limit the vessel in which the liquid is contained and is transmitted to all points in the liquid, progressively increasing with depth. He carried out important experiments with atmospheric pressure, concluding that it progressively decreases with altitude. In 1647 he published the results of his observations surrounding Torricelli's hypotheses about the physical nature of the vacuum. Pascal[(3)] wrote the Traité de l'équilibre des liqueurs, a famous treatise on hydrostatics, which was only published a year after his death (1663). With this work, he revolutionized mechanical engineering, describing the principles for the construction of the hydraulic press, a device that allows the multiplication of the applied force. Pascal thus left the famous PASCAL PRINCIPLE for the history of Physics: “in a liquid at rest or equilibrium, pressure variations are transmitted equally and without loss to all points of the liquid mass”. Due to his important contributions, in his honor, Mechanics has a unit of pressure called PASCAL. At the age of twenty-eight, in 1651, on visits to the Paris gaming hall, he became curious to know the probability of a player getting a certain face of a dice in a certain number of moves. So he created Probability Theory. At the age of 35, in 1658, Pascal published another important scientific work Traité du triangle arithmétique, where he studied the properties of Pascal's famous Triangle. This is an array of numbers used to calculate binomial coefficients that is constructed by adding two adjacent numbers in a row and placing their sum in the next row down. This was very useful in future studies of Combinatorial Analysis. Pascal was also interested in Mathematics by infinitesimal calculus, by sequences, having enunciated the principle of mathematical recurrence. Pascal[(4)] , although in a short life, dedicated himself to numerous relevant activities, including standing out as an entrepreneur. Together with his sister Jaqueline, he also provided important social and educational assistance services to the French community. He created a method and booklets for teaching French to children. In 1653, he transferred to the convent-school in Port Royal, also to be closer to his sister Jacqueline, who had opted for religious life. His health, after a few illusory improvements, deteriorated more and more; however, without giving up, he still promoted several scientific studies. The works on the cycloid stand out, publishing in 1658 a series of works[5] on the quadrature of the cycloid. This was his last scientific work. On August 19, 1662, aged just 39, he died at the home of his sister Gilberte.

SUMMARY OF SOME OF PASCAL'S CONTRIBUTIONS TO SCIENCE

ESSAI SUR LES CONIQUES

The Essai pour les coniques[6] in 1640 was Blaise Pascal's first publication when he was just sixteen years old. Pascal's purpose with this publication seemed to be to call the attention of the scientific community to his discoveries, including indicating the date of their realization, as well as to announce the elaboration of a more comprehensive work (the Éléments coniques complets referred to in the text), and, if we believe in the modest conclusion of the text, that of receiving reactions from readers about the content presented there. presents a work program based on what Girard Desargues (1591–1661) had already found about the perspective approach to conics. This justifies the fact that it is an essay “for” conics: namely, for a treatise on conics that Pascal announced that he would present. The fact that Pascal's treatise on conics has been lost almost entirely leads us to value even more the Essay for Conics, despite the fact that it is a short work. It is, therefore, a pamphlet that had a great repercussion, as it presented a particular case of what would later be called Pascal's Theorem, or Hexagon Theorem: the alignment of the intersection points of three pairs of opposite sides of a hexagon inscribed in a conic. In addition, he presented an approach to the study of conics that can be called “projective”. Before dealing with how this theorem is presented, let's see briefly what are the mathematical contents of the Essay for conics, as well as what is its relation with “projective geometry”. The Essay for Conics presents three definitions, three lemmas and five theorems, all presented without proofs, in addition to three construction problems, briefly stated. The first definition, of lines of the same “order” or of the same “ordinance”, allows Pascal to deal simultaneously with concurrent lines and parallel lines. The second definition, of “conic section”, reveals how Pascal unifiedly conceives conic sections (circle, ellipse, hyperbola, parabola and rectilinear angle). The third definition brings a vocabulary precision to the “lines”. The first lemma presents a version of Pascal's Theorem for the case of the circle, and the third lemma a version of the theorem for any conic. In fact, it is an equivalent result, because here it is not a question of hexagon. The second lemma presents a simple result of spatial geometry. Pascal then announces the deduction of several consequences from these lemmas and their consequences, which would constitute a complete treatise on conics. As an example of this general approach, he presents five theorems in the text.

LA PASCALINE

The first automatic calculating machine would only appear around 1642. La Pascaline[7] was developed by Pascal, who for the first time used a system of gears with toothed wheels that allowed calculation through mechanical transport movements to perform sums. Each “tooth” corresponded to a number, from 0 to 9. The first wheel on the right corresponds to units, the one immediately to its left corresponds to tens, the next one to hundreds and so on. A very simple mechanism built with a “claw” solved the transportation problem. Each time the digit goes from nine to zero on one of the wheels, the neighboring wheel is dragged and a tooth is moved. The calculator allowed to carry out addition and subtraction operations – complement method. A little later, in 1694, the German mathematician Von Leibniz developed a similar machine that performed multiplications through successive additions. A pascaline is a rectangular box approximately 30 centimeters long and 8 centimeters high. In the upper part of the machine, there are 8 rotating disks divided according to the number of units each one works with. On each disk there are a total of two wheels, which serve to determine the number with which one works on each one. Above each disk is a number, which changes according to the way in which each wheel is placed. Each of the numbers is behind a small window (that is, an opening that allows you to see the number drawn on paper). There is a small metal bar next to where the numbers are located which must be placed if you want to use the machine to add. The interior of a pascaline is the composite of the entire counting system that allows the device to calculate addition and subtraction. This counting mechanism records the number of wheel spokes each shift performs. The hardest part of the mechanism is that when one of the wheels makes a complete turn (that is, it adds up as many numbers as it allows), it must register the complete turn on the next wheel. In this way, it is possible to add greater than 10 numbers. This movement, which allows the complete return of one of the mechanisms to another contiguous mechanism, is called transmission. Explaining everything in a simple way, the right wheel of each mechanism is considered as the units wheel, while the left is considered as the tens wheel. Every 10 turns of the right wheel represents one of the left wheel (i.e. 10 units represents a ten). All wheels rotate counterclockwise. In addition, there is a mechanism that acts in the form of an arm, which stops the movement of the wheels when no addition or subtraction is being carried out. With this mechanism, Pascal ensured that Pascalina's wheels could only be placed in fixed positions, which prevented the irregular movement of the pieces. Thus, the calculations were more accurate and the machine's margin of error was reduced.

Between each mechanism is a lever, often referred to as a transmission lever. This lever helps the wheels register the rotation of all adjacent wheels. This wheel consists of a series of different parts that allow its operation. Also, you can spin it independently of the wheel it's attached to. This movement is determined by the drive pin, which is attached to the flywheel. The lever has some springs and small mechanisms that allow it to change position as the rotation of the wheel determines its need. The spring and a piece specialized in pushing the lever make it move depending on the direction in which each wheel turns. By this process, when the left wheel completes a turn, the right wheel moves once (to the next peg out of the total 10 pegs). It's a pretty complex mechanism. The design was particularly difficult to achieve at the time, which made each piece quite complicated to build and the pascaline was a very expensive object. In many cases, it was more expensive to buy a pascaline than to pay for a middle-class family's subsistence for an entire year. The machine process mainly made it possible to efficiently add and subtract two-digit numbers without having to resort to manual calculation systems. At that time, it was very common to calculate numbers using writing or simply using an abacus to perform individual calculations. However, these systems used to take a lot of time for people. For example, Pascal's father came home after midnight after spending most of the day counting numbers by hand. Pascal developed this tool to speed up calculation work.

PROBABILITY THEORY

Before Pascal's time there was no theory of probability, only an understanding of how to compute the 'odds' in games with dice and cards counting equally likely outcomes. Furthermore, problems encountered in enumerating dice throws and counting arrangements and selections of things led to an incipient mathematical theory of combinations and permutations, but the rules that appeared in the works of authors such as Tartaglia and Cardano still had the form of recipes and not as parts of a coherent whole. It fell to Pascal[8] to bring the separate threads together and weave them into a structure that would allow him to progress far beyond his predecessors, introducing entirely new mathematical techniques for solving problems that had hitherto resisted solution, techniques that became the basis of modern probability theory. Pascal's influence was not direct, as none of his writings on probability were published during his lifetime, but was instead transmitted via Huygens to James Bernoulli, where it appeared in the latter's influential Ars conjectandi of 1713, and through the Essay d' analyze sur les jeux de hazard de Montmort, first published in 1708. These two books, along with De Moivre's The Doctrine of Chances, firmly established probability theory as a branch of mathematics. Later scholars confirmed the view that Pascal[9] can rightly be considered the father of probability theory.

PASCAL'S TRIANGLE

Triangle formed by binomial numbers, as the name suggests, is an infinite arithmetic triangle organized by binomial coefficients. This triangle[10] is divided into rows and columns, which start from the number 0 (zero). Binomial coefficients, also called binomial numbers, are represented as follows:

$$\binom{n}{p}$$

The number “n” is the numerator and “p” denominator, n and p are natural numbers where n ≥ p. This binomial number is calculated using the expression below:

$$\binom{n}{p} = C_{n,p} = \frac{n!}{p!(n-p)!}$$

Where:

C_{np} indicates simple combination with n elements taken p to p;

n! denotes the factorial of any integer n

p! denotes the factorial of any integer k.

In Pascal's triangle, the binomial coefficients are arranged in such a way that the coefficients of the same numerator occupy the same row, while the coefficients of the denominator occupy the same column. See in the image below:

Linha 0 $\binom{0}{0}$

Linha 1 $\binom{1}{0}\binom{1}{1}$

Linha 2 $\binom{2}{0}\binom{2}{1}\binom{2}{2}$

Linha 3 $\binom{3}{0}\binom{3}{1}\binom{3}{2}\binom{3}{3}$

Linha 4 $\binom{4}{0}\binom{4}{1}\binom{4}{2}\binom{4}{3}\binom{4}{4}$

Linha 5 $\binom{5}{0}\binom{5}{1}\binom{5}{2}\binom{5}{3}\binom{5}{4}\binom{5}{5}$

Linha 6 $\binom{6}{0}\binom{6}{1}\binom{6}{2}\binom{6}{3}\binom{6}{4}\binom{6}{5}\binom{6}{6}$

Remembering that both lines and columns start at 0. The fifth line has five binomial numbers, all with numerator four. As well as in the third row, all binomials have the number two in the denominator. In a simplified way, we can state[11] that the numerator of all the binomials that are in a line is the same. Just as the denominator of all binomial numbers in a given column is equal to the column number. In Pascal's triangle the lines have finite elements, which correspond to the respective number of the line added to one. For example, the fifth row has four in the numerator which added to one equals five. Pascal's triangle can be used in various probability conditions. Suppose that if we are tossing the coin once, there are only two possibilities of getting outcomes, Heads (H) or Tails (T). If we flip twice, there is a possibility of getting both heads HH and both tails TT, but there are two possibilities of getting at least one heads or one tails, i.e. HT or TH. Using Pascal's triangle we can easily solve this problem.

FINAL CONSIDERATIONS

Pascal's great contribution to the philosophy of mathematics came with his De l'Esprit géométrique[12] , originally written as a preface to a geometry book for one of the famous "Petites écoles de Port-Royal". The work remained unpublished until more than a century after his death. Here, Pascal studied the issue of truth discovery, arguing that the ideal of such a method would be to find all propositions about already established truths. At the same time, however, he claimed that this was impossible because such established truths would require other truths to support them - first principles therefore could not be attained. On this basis, Pascal argued that the procedure used in geometry was as perfect as possible, with some principles assumed and other propositions developed from them. However, there was no way of knowing whether the assumed principles were, in fact, true. Pascal also used De l'Esprit géométrique to develop a theory of definition. He distinguishes between definitions that are conventional labels defined by the writer and definitions that are within the language and understood by everyone, as they naturally designate their referent. The second type would be characteristic of the philosophy of essentialism. Pascal claimed that only definitions of the first type are important for science and mathematics, arguing that these fields should adopt the philosophy of formalism as formulated by Descartes. In De l'Art de persuader", Pascal[13] studied more deeply the axiomatic method of geometry, specifically the question of how people come to be convinced of the axioms on which later conclusions are based. Pascal agreed with Montaigne that reaching certainty in these axioms and conclusions through human methods is impossible.He asserted that these principles can only be apprehended through intuition, and that this fact underscored the need for submission to God in the search for truths.

CONCLUSION

We would have much more content to introduce in this short summary, but we will end by saying that we are facing a stratum of the work of a scientist who died very young. He lived very little, but he was able to leave masterpieces in the short time he had, and he will always be remembered as an impressive talent that premature death did not allow to fully blossom. With the development of this scientific article, one can better understand the life of Blaise Pascal and his consecrated work. We present some biographical data of the author and his relationship with the work itself, and a summary of the narrative was also made. Subsequently, some considerations were made about both, highlighting the importance of the work in question for Pascal to be considered a brilliant scientist. Thus, this study is considered important for all those who somehow show an interest in the History of Science, especially academics, since they certainly need to know about the subject to possibly apply it in the exercise of their profession.

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