



## Foundation of a millenary civilization: Egypt and the origin of mathematical measurement systems



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### ABSTRACT

The ancient civilization of Egypt left a significant mark on the evolution of mathematical concepts, which is considered to be of great importance due to its influence in this field. The ancient Egyptian mathematicians set important precedents in modern mathematics through their innovative approach to solving practical problems that for their time must have been of a high level of complexity.

In ancient Egypt, applications were based on the decimal system and mathematical techniques were fundamental in their day-to-day life. The Egyptian numeral system, which used multiples of ten and particular hieroglyphics, offered an efficient way to perform mathematical operations and manage resources. This non-positional approach, in which the value of a symbol did not depend on its position in the number, allowed the Egyptians to perform complex tasks related to accounting, architecture, and astronomy.

One of the main characteristics of Egyptian mathematics was its use in everyday life. In administrative management, notaries employed the ten-number system to record assets and taxes on papyrus documents, simplifying resource management and accounting. In the planning and construction of monuments such as the pyramids, Egyptian mathematics was instrumental as precise calculations were needed to measure and calculate proportions. In addition, the decimal system was used in astronomy for the tracking of astronomical cycles and the elaboration of calendars, which was essential for agriculture and religious structure.

Egypt's mathematical heritage not only had an impact on contemporary mathematical practice, but also developed the foundation for future advances in this discipline. Despite being non-positional, the Egyptian numeral system, with its base 10 and methods of calculation, impacted later numerical systems and the advancement of Greek and current mathematics. Research of Egyptian mathematical papyri, such as the Rhind Papyrus, reveals how.

**Keywords:** Trigonometry, Algebra, Geometry, Development, Knowledge.

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## INTRODUCTION

The structural essence of this work is based on the investigation of unpublished events that support the origin of Egyptian civilization, considering its cultural development, mathematical contributions and how the path of development of this society is marked.

The foundation of a millenary civilization arises from the need to understand how our ancestors were able to adapt and create a "Decimal" system, sets of basic and complex operations that today are the basis of the great diversity of calculations that we find in mathematics.

It can be said that the main unknown for our time is how we can project mathematics in a more efficient, interactive way and with easy internalization of concepts?, It is from this collected information where we can define edges that allow us to understand concepts and have a better focus of analysis on the integral development of this civilization, that in all their splendor and walk recorded all their contributions on a natural sheet called papyrus.

Writings so valuable that, even in our times, they are the records that support the theory and concept of algebra, trigonometry, arithmetic and above all that give rise to the emergence of other exact sciences.

The study of Foundation of a Millennial Civilization focused on the decimal system seeks to publicize the positive impact of the mathematical legacy interposed by Egypt and how this civilization was able to create a system of measurements for interaction with mathematical problems that allows us to have a close relationship with a mathematics model of greater functionality and better understanding.

It is intended that this work will serve as cultural and mathematical enrichment, being used as a didactic resource in the learning process of future generations.

## THEORETICAL OR CONCEPTUAL ELEMENTS

Egypt, located in northeastern Africa, flourished around 3100 B.C. until the conquest of Alexander the Great in 332 B.C. During this period, the Egyptians developed an advanced civilization with a practical focus on mathematics, geared primarily toward solving everyday and administrative problems. The need to measure land, build monuments, and manage resources encouraged the development of basic mathematical concepts.

In relation to the latter, we can see that the Egyptians were faced with the need to perform calculations and consider dimensions to, for example, carry out their constructions, a situation that challenged them to find some way to represent the quantities used. In addition, we see that they represented the figures used in papyri, giving them a use, mainly related to geometry and arithmetic.

One of the contributions that represents them the most is the base 10 system or decimal system, which means that it was based on multiples of ten. He used different symbols to represent



units (1 to 9), tens (10 to 90), and hundreds (100 to 900). This decimal base is the same as that used in most modern numbering systems, demonstrating the enduring influence of the Egyptian system.

This system influenced subsequent mathematical developments, since it allowed them to perform arithmetic, trigonometric and algebraic operations, as well as calculate areas, taxes and other types of values that were undoubtedly beneficial for them to establish their foundations as a society.

By understanding the mathematical legacy of decimal development, we can appreciate the importance and ingenuity of ancient civilizations that manage to project the development of mathematics today. America (1927)

## STRUCTURE OF THE EGYPTIAN DECIMAL SYSTEM

### HIEROGLYPHIC NUMBERING

The decimal system in Egypt was expressed by hieroglyphics, with specific symbols representing units, tens, hundreds, thousands, and so on. Key symbols include:

- 1: Represented by a vertical cane (|).
- 10: Represented by a coiled rope (☉).
- 100: Represented by a papyrus scroll (☐☐☐).
- 1,000: Represented by a lotus (𐊚).
- 10,000: Represented by a pointing finger (𐊕).
- 100,000: Represented by a tadpole (𐊖).
- 1,000,000: Represented by a man with his arms raised (𐊗).

Numbers were formed by combining these symbols, with hieroglyphs arranged repetitively to indicate multiples. For example, the number 2,345 would be written by combining two lotuses (2 x 1,000), three papyrus scrolls (3 x 100), four coiled ropes (4 x 10), and five upright sticks (5 x 1).

### NON-POSITIONAL SYSTEM

A distinguishing feature of the Egyptian decimal system is its non-positional nature. Unlike the modern decimal system, where the value of a digit depends on its position, in the Egyptian system each symbol had an absolute value, regardless of its position. This means that the calculation required the sum of the values of the symbols, which made the mathematical operations more laborious and manual. Neugebauer (1969)



## APPLICATIONS OF THE DECIMAL SYSTEM IN EGYPTIAN LIFE

### ACCOUNTING AND ADMINISTRATION

The decimal system was central to the administration of the Egyptian state, particularly in the accounting of goods, tribute, and forced labor. Scribes used this system to record quantities of grain, livestock, and other resources in administrative papyri. This practice was so widespread that mastery of the decimal system was essential for those involved in public administration.

### CONSTRUCTION AND ARCHITECTURE

The use of the decimal system was crucial in the planning and construction of monuments such as pyramids and temples. Architects and workmen used this numbering to measure and calculate proportions in structures, ensuring precision in dimensions. Documents such as the Rhind Papyrus contain mathematical problems related to geometry, reflecting the practical use of the decimal system in construction.

### ASTRONOMY AND CALENDAR

The Egyptians also applied the decimal system in astronomy, particularly in the observation of astronomical cycles and the creation of calendars. They used units of measurement based on multiples of ten to calculate time and predict astronomical phenomena, which was vital for agriculture and religious organization.

## DEVELOPMENT OF EGYPTIAN MATHEMATICS

### MATHEMATICAL PAPYRI

The Rhind Papyrus (c. 1650 BCE) and the Moscow Papyrus are two of the most important documents showing the use of the decimal system in mathematical problems. These texts contain arithmetic and geometric problems solved by the decimal system, which evidences an advanced knowledge of mathematics on the part of the Egyptian scribes.

- **Unit Fractions:** Although the Egyptian decimal system did not use a place zero, it did use unit fractions, in which each fraction was expressed as the sum of fractions with a numerator one (e.g.,  $2/3 = 1/2 + 1/6$ ). This system of fractions was fundamental in calculations related to the distribution of resources and the division of land.

### CALCULATION AND GEOMETRY

The Egyptians solved geometric problems, such as the calculation of areas and volumes, using their decimal system. For example, they could calculate the area of a circle or the volume of a



cylinder by applying formulas that were derived from empirical observations and precise measurements. Neugebauer (1969b)

## **CULTURAL IMPACT AND LEGACY OF THE EGYPTIAN DECIMAL SYSTEM**

### **INFLUENCE ON OTHER CULTURES**

The Egyptian decimal system influenced the number systems of other ancient cultures. Through trade and conquest, elements of Egyptian numerals were passed on to neighboring civilizations, such as the Greeks and Romans. Although these systems evolved into more advanced positional systems, the decimal base and some symbols continued to be used.

### **LEGACY IN MODERN MATHEMATICS**

Although the Egyptian decimal system did not survive in its original form, its legacy lives on in the history of mathematics. The concept of base-10 counting is a universal practice that probably originated, at least in part, in Egyptian mathematics. In addition, the calculation methods and geometric approximations developed by the Egyptians laid the foundation for Greek mathematics and, ultimately, modern mathematics. Neugebauer (1969b)

### **ADVANCES THANKS TO THE DECIMAL SYSTEM TODAY:**

#### ✓ Advanced Mathematics:

**Calculus:** The decimal system allowed the development of differential and integral calculus.

Decimal notation simplified the representation of fractional and decimal numbers, making it easier to work with boundaries, derivatives, and integrals.

**Algebra:** The adoption of the decimal system allowed for the development and expansion of algebra. Equations and algorithms became more manageable and accurate.

#### ✓ Data Science:

**Measurement and Statistics:** The ability to represent and manipulate numbers with decimal precision improved accuracy in data collection and analysis, essential for statistics and scientific research.

**Computation:** The decimal system is the basis for the representation of numbers in computer systems and databases, although computers operate internally in binary. Decimal to binary conversions are critical to data processing.

#### ✓ Astronomy:

**Orbit Calculation:** Accurate calculations of planetary orbits and celestial motions depend on the use of the decimal system to handle large numbers and small fractions.



Observations and Measurements: Decimal notation allowed to improve the accuracy of astronomical measurements and in the representation of astronomical data.

✓ Physics:

Theory of Relativity and Quantum Mechanics: Decimal precision is crucial in the equations of modern physics, such as those of Einstein's general relativity and the equations of quantum mechanics.

Scientific Instrumentation: Accuracy in the measurement and calibration of scientific instruments benefits from decimal notation.

✓ Engineering:

Design and Construction: The decimal system allows precision in the design and construction of structures, machinery, and technology. Accurate calculations are essential for civil, electrical, and mechanical engineering.

Simulations and Models: Decimal notation facilitates the development and analysis of complex computer simulations and models.

✓ Economy and Finance:

Economic Models: Economic and financial models use the decimal system to represent and analyze economic data, perform financial calculations, and develop economic theories.

Accounting: Decimal notation is critical in accounting to perform accurate calculations and handle large volumes of financial data.

✓ Chemistry:

Concentrations and Reagents: Decimal notation is used to express concentrations of solutions, proportions of reactants, and in stoichiometry calculations.

In short, the decimal system has been essential for the advancement of science and technology. Its ability to accurately represent numbers has facilitated developments in mathematics, physics, engineering, and other scientific disciplines. Davis (2017b)

## DESCRIPTION

The elaboration of this research work is based on a requirement to opt for the Bachelor's degree in Mathematics from the National University of Panama and was prepared with the participation of professors Alcibiades Medina, Eliecer Cedeño and Narciso Galástica, professors of the University of Panama. It is elaborated in chapters that represent the most relevant aspects of the Egyptian legacy in mathematical development, such as its historical evolution, decipherment of mathematical contributions made and a wide relevance to the great scientific contribution and culture of these regions to our society.



The limitations presented in the research can be referred to the lack of texts completely focused on this type of mathematical advances or mathematical epistemology.

The need to be able to expand the research as a result of the lack of translation of certain writings in papyri that undoubtedly when we reach solve we could find a greater number of contributions that will finally continue to support the value of Mathematics as the mother of all sciences.

## **FINAL THOUGHTS**

Through the hieroglyphic writing system, the ancient Egyptians developed a set of mathematical knowledge that ranged from simple arithmetic calculations to geometry problems and advanced algebra. Their decimal numbering system, based on base-10 figures, allowed them to perform complex operations and solve practical problems of everyday life.

Mathematics in ancient Egypt was applied in various fields, such as administration, architecture, commerce, and astronomical measurements. His approach to solving problems and his determination to fix concrete concepts demonstrate a deep mastery of mathematical applications, considering a particular way of synthesizing procedure.

It is crucial to reaffirm that Egypt's mathematical legacy influenced later civilizations, such as ancient Greece, India, China, etc., and laid the foundation for the development of mathematics in the world. Concepts such as statistics, congruences, and solving systems of logarithmic and quadratic equations have their roots in the mathematical contributions of ancient Egypt.

As a general recommendation, I consider that it is necessary to highlight and at the same time expand the importance of the decimal numbering system used in educational writing and how it is applied in calculations and measurements, in addition to exploring and analyzing the content of the papyri, focusing on those that contain mathematical records that allow us to take our work as mathematicians to a didactic level full of broad methodologies in order to generate a more efficient impact in this science.



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