science & technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NUMBERS OLD AND NEW

All languages have words for numbers, but only when a culture has developed a way of recording numbers, can arithmetic and mathematics be advanced. When ancient civilizations in the Middle East, notably Egypt and Mesopotamia, developed writing, the way they wrote was determined by what they wrote on. In Egypt they wrote with pen and ink on papyrus, made from a reed that grows in the Nile. In Babylon they wrote on soft clay tablets with a pointed stick. The tablets were then baked hard in the sun. Paper was invented in China, where they wrote with fine brushes. In Rome the scribes used a tablet coated with wax, which could be used more than once. Permanent records were written on parchment, made from soft leather. Today we use a number system transmitted to the West from India, by Arabic scholars. But we still use Roman numerals on clocks, on gravestones and memorials, and in recording dates. We also still use the most primitive form of recording numbers 1 (|), 2 (||), 3 (|||), 4 (||||), 5 (~~||||~~), etc.

MODERN NUMBERS

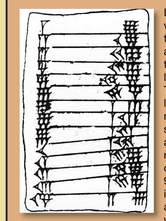
The numbers we use today originated in India. In 825 AD the Persian mathematician Al-Khwarazmi wrote a book in Arabic called *On calculation with Hindu numerals*. This work was translated into Latin as *Algoritmi de numero Indorum*. The translator put the author's name in a Latin form, "Algoritmi", from which our word algorithm is derived. In 1202 Leonardo Fibonacci promoted the Indian system in his influential *Book of the Abacus*, and the "Hindu-Arabic" numbers replaced Roman numerals in the West. For some time both the old Roman numerals and the new Hindu-Arabic system were used. Roman numerals are well-suited to calculations on an abacus, but calculations with the new numbers were done on paper.

Numbers used today in the Arab world came from the same Hindu source, but are different. The telephone keypad shows the two forms of Arabic numerals still in use today.

The picture shows a maths competition five hundred years ago. On the left, Boethius is using the new Hindu-Arabic system. On the right, Pythagoras is using an abacus. Behind them, the Goddess Arithmetica is keeping score. Judging from the smile on the face of Boethius, and the worried look of Pythagoras, the new number system is winning.

1 A BABYLONIAN NINE TIMES TABLE

More than 3000 years ago the people of Babylon (modern-day Iraq) devised a system of writing on clay tablets, which were then baked hard in the sun. Thousands of these clay tablets have been discovered by archaeologists, who have learnt to read them. Babylonian writing used just two symbols, a vertical wedge 𒁹 and an angular wedge 𒌋. Their writing is called cuneiform ("wedge-shaped"). The writing of numbers in cuneiform is easy to figure out.

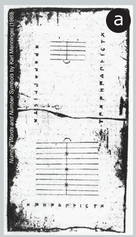


This clay tablet was used in a Babylonian classroom about 3500 years ago.

Look at the tablet. The first nine groups of wedges down the left hand column are clearly the numbers from 1 to 9. Then there is a single angular wedge 𒌋, which clearly represents ten. It is followed by 11, 12, 13 and 14. Now look at the numbers in the right hand column. The first six are 9, 18, 27, 36, 45 and 54. It looks like a nine times table. So the next number 𒁹 𒁹𒁹 should be 63, and we see that the first vertical wedge is now used again to represent 60, separated from the group representing 3. Going on down the column, we can now read the numbers the numbers 72, 81, 90, 99, 108, 117 and 126. In the last number, 120 is represented as two sixties: 𒁹𒁹. The people of ancient Babylon counted in tens and sixties. The way we divide time (60 seconds in a minute and 60 minutes in an hour) and angles (60 minutes in a degree) comes from ancient Babylon.

2 THE ABACUS
(the world's oldest calculator)

The abacus was developed thousands of years ago as a way of doing calculations. Originally it was a flat surface of stone marked with parallel lines on which small stones were placed.



A marble abacus from Salamis, in Greece (300 B.C.)

Japanese abacus (soroban)

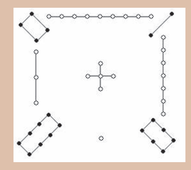
Two thousand years ago the Romans devised the first hand-held calculator. It was made of bronze, with pegs sliding in slots. The three slots on the right of the abacus were used for calculations with fractions. The main slots are for units, tens, hundreds etc are marked with the Roman numerals I, X and C. Note that the symbol on this abacus for a thousand is (|), not M. Ten thousand was written ((|)), a hundred thousand was written (((|))), and a million was written ⌧.

An Afghan shopkeeper using an abacus

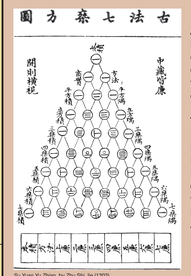
Today the abacus is usually a frame with beads sliding on wires. A number of different forms of the abacus are still used today in Japan, Russia and China.

3 NUMBERS IN CHINA

The Lo Shu diagram is thousands of years old and was used in Chinese fortune-telling. The numbers from 1 to 9, represented by groups of dots, are arranged in a square so that the sum of the numbers in each row, column and diagonal is 15. Today we call such an arrangement of numbers a Magic Square.



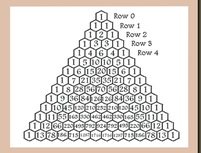
4	9	2
3	5	7
8	1	6



Su Yuan Yu Zhian, by Zhu Shi Jie (1303)
from *Science and Civilization in China*, by Joseph Needham (1959)

Another way of writing numbers in China was "rod numerals". Look at the numbers in the triangle of circles below. In the top circle there is a single horizontal rod, representing 1. After that, each number is the sum of the two numbers immediately above it to the right and left. Knowing the rule, the Chinese rod numerals can be worked out.

This arrangement of numbers is known as Pascal's Triangle, after the French philosopher and mathematician Blaise Pascal (1623–1662). However, the number triangle was known to Chinese, Indian and Persian mathematicians hundreds of years before Pascal was born. It has many important applications in mathematics today.



4 FINGER COUNTING

All over the world, people count in tens. The reason is simple: we all have ten fingers. We use the word "digit" to mean either a finger, or a number. We do simple calculations on our fingers, and use our fingers to pass on number information across a crowded noisy room.

In busy African markets, traders and customers use finger numbers to bargain in secret. They hide their hands under a cloth and make their offers and counter-offers to each other using finger numbers.

Summa de arithmetica, by Luca Pacioli 1494 from *The Universal History of Numbers*, by George Ifrah (1998)

Finger arithmetic was once taught in school. The chart, from a 1494 Italian textbook of arithmetic, shows a system of finger counting.

5 THE AFRICAN STONE GAME

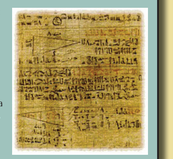
Mancala is a counting game played all over Africa. The game involves distributing stones around a board so as to capture one's opponent's stones. It is known under many different names: onweso in Uganda, lela in the Congo, wari in Ghana, soro in Tanzania. Julius Nyerere, the first President of Tanzania, was a champion soro player.

A 1911 photograph of wives of African chiefs playing oware in northern Cameroon

6 EGYPTIAN HIEROGLYPHIC NUMBERS

The Egyptians were one of the earliest civilisations to develop writing, called hieroglyphics. They had special symbols for numbers.

Papyrus scrolls nearly four thousand years old show us that the Egyptians were skilled in mathematics. They had a good calendar (our modern calendar is a direct descendant). They knew how to calculate the area of a circle (using 3.16 as an approximation to π) and the volume of a pyramid.

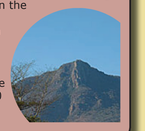


The Ahmes papyrus (c. 1650 B.C.)

Egyptian hieroglyphic numbers

7 THE LEBOMBO BONE
(the oldest mathematical tool)

Writing first developed in the Middle East, in the cuneiform texts of Mesopotamia and the hieroglyphics of Egypt. However, the recording of numbers is much older, and the earliest records of numbers can be found in Africa. A piece of the fibula (shin bone) of a baboon, just 7.7 cm long, was found in a cave in the Lebombo Mountains between South Africa and Swaziland.

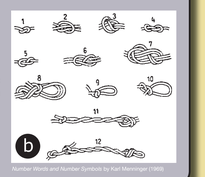


The bone is clearly marked with 29 notches and resembles calendar sticks still in use today by San clans in Namibia. It may have been a record of the days from one full moon to the next. Archaeologists have dated the Lebombo Bone to 35 000 B.C. It is the oldest example in the world of the permanent recording of a mathematical idea.

8 NUMBERS ON STRINGS

The Incas of Peru developed a system of recording numbers on knotted strings, woven from the hair of alpacas or llamas. These strings, called quipus, were used in doing arithmetic, working out taxes, carrying out a population census and keeping track of the calendar. Quipus are still used in some remote villages in Peru. The Incas were not the only people to use knotted string to record numbers.

In Germany, up to the end of the 19th century, millers used knots to record the amount and type of flour in their sacks. One unit of flour was indicated by a simple overhand knot, two measures by a simple knot with an extra string passed through it, and a figure eight knot was used for five units. Loops at the end of the string recorded the type of flour in the sack.



Number Words and Number Symbols by Karl Menninger (1969)

9 MAYAN NUMBERS

The Mayan civilization in Central America (now Mexico) used a simple system of dots for units and bars for fives. They also had a symbol for zero.

Each number had its associated god, and for ritual purposes and on monuments the faces of the gods represented the numbers.

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