

## Mathematics

Intellectuals in 16th and 17th century Europe began the modern era of mathematical and scientific discovery. Some of these mathematicians, such as Descartes, Fermat, Leibniz, and Newton, are today considered among the greatest thinkers of all time.

### Text

The origin of our human ability to do mathematics fades into prehistory. Even so, the first records of an advanced written mathematics date back to ancient Egypt and Babylonia over five millennia ago. The most accomplished mathematicians of ancient times were the Greeks, such as Pythagoras (c. 580 BC-c. 500 BC) and Euclid (c. 330 BC-c. 260 BC). They created an approach to geometry based on logic and proof. Euclid detailed much of this knowledge in his text the *Elements*. This book retained the Greek mathematics through the Dark Ages, returning to Europe via Islamic scholars in the 13th century.

This mathematical knowledge of the ancient Greeks and some new Arabic developments gradually spread across Medieval Europe. By the Renaissance there were many skilled mathematicians. Many of these individuals had other occupations, while some were fortunate enough to have independent funds.

### Algebra and geometry

Modern mathematics is based on algebra, where symbols and letters represent unknown quantities. Mathematical equations then relate the possible value of these quantities to each other. For example,  $y=3x$  means that the value of  $y$  is three times that of  $x$ . This language of mathematics is fundamental to all modern science. It gradually became widespread after about 1500 AD.

Italian and German mathematicians pieced together the symbols of modern algebra between the 14th and 16th centuries. At first mathematicians used this new language of equation to look at ancient problems in Greek geometry. In particular, the French mathematician François Viète (1540-1603) solved many outstanding classical problems, such as constructing a circle that just touches three other circles. He collected his major work in the influential 1591 book *In artem analyticem isagoge* (Introduction to the analytical arts).

Viète's analytical arts greatly influenced the famous 17th century French mathematicians Pierre de Fermat (1601-1665) and René Descartes (1596-1650). Fermat extended Viète's work and discovered some main principles of modern algebraic geometry. At the same time Descartes finally put mathematics in the completely modern form familiar today. Among his many results he created the Cartesian coordinate system, where three numbers label the position of any point in space. This concept is vital to science, map-making, and underlies later mathematical disciplines such as calculus.

### Newton and Leibniz's Calculus

Calculus has been indispensable to mathematicians since its discovery in the 1670s. Jointly formulated by British scientist Sir Isaac Newton (1642-1727) and German intellectual Gottfried Wilhelm Leibniz (1646-1716), it has since spread as a mathematical technique for almost all physical theories and engineering principles. In a sense, the widespread use of calculus separates the modern period of advanced mathematics and science from its more primitive roots.

Mathematically, calculus is a set of methods for describing how one quantity smoothly varies with another. For example, the height of a curve will continuously change as one traces along it. A particular use of calculus is to find the rate at which quantities change. For the smooth curve, the rate its height changes with the distance moved across is called its slope or gradient. Another use of calculus is to find the areas and volumes of various shapes and solids. This is because the area under a curve is in a mathematical sense the opposite of its slope.

Newton described his version of calculus in his monumental work the *Philosophiæ Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy), first published in 1687. He used these mathematical techniques to deduce the laws of motion and gravity. These were universally accepted until Albert Einstein (1879-1955) discovered his theories of relativity in the early 20th century.

#### Chance and probability

European mathematicians founded another important subject toward the end of the Renaissance—probability theory. This discipline describes how to calculate the chance of a situation occurring, using a number between zero (never happens) and one (always happens) to quantify its likelihood. For example, a six-sided dice has a one in six chance, or a probability of one-sixth, of landing on a six when thrown.

Two individuals particularly stand out for their contributions to the science of chance. French mathematicians Pierre de Fermat and Blaise Pascal (1623-1662) collaborated by letter and jointly founded the mathematics of probability theory. Later, the French mathematician Abraham De Moivre (1667-1754) extended many of these ideas in his book *The Doctrine of Chances* (1718). De Moivre's love of gambling most likely influenced his work, the winnings from which he used to fund his mathematics research.

#### Box: A bitter rivalry

When Sir Isaac Newton and Gottfried Wilhelm Leibniz independently discovered the mathematics of calculus they became embroiled in an angry dispute over who came first. Newton appears to have asked British scientists to claim that Leibniz plagiarized his work. Leibniz appealed to the Royal Society of London, but Newton (the society's president) chose a jury that found Leibniz guilty.

In his later life Leibniz became bitter and disheartened. Yet history has shown him to prevail in the dispute. His feud with Newton caused a rift between British and continental scientists through the 18th century. British mathematics languished, while continental science thrived.

These discoveries used Leibniz's style of mathematics. Therefore his notation and methodology is still used today, not Newton's.

Box: Fermat's last theorem

Although a magistrate by trade, Pierre de Fermat made many important discoveries in probability theory, geometry, and algebra. His most famous result was found scribbled in a margin of an ancient Greek text after his death. Next to the equation  $x^n + y^n = z^n$  he noted that there are no solutions with  $x$ ,  $y$ , and  $z$  whole numbers and  $n$  larger than two, saying: "I have discovered a truly marvelous demonstration of this proposition that this margin is too narrow to contain."

Fermat's equation looks deceptively simple. The symbol  $x^n$  means "x to the power n," or x multiplies x multiplies x multiplies ... for n times. Thus the case when n is two is easily disproved with  $3 \times 3 + 4 \times 4 = 5 \times 5$ . Yet no mathematician could verify or falsify Fermat's statement for other values of n. Finally in 1995 the British mathematician Andrew Wiles (1953-) proved Fermat's theorem. His proof spans over one hundred pages.

Box: See also

Astronomy  
Descartes  
Leibniz  
Newton, Isaac  
Science