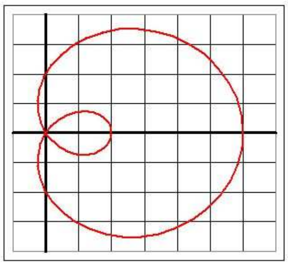
BLAISE PASCAL (June 19, 1623–August 19, 1662)

by HEINZ KLAUS STRICK, Germany

BLAISE PASCAL was the second child of ÉTIENNE PASCAL, a judge at the taxation court in Clermont-Ferrand, France. Three years later, the boy's mother died, and his father decided to educate the children himself. In 1632, he sold his judicial office in the hope of establishing a life in the French capital with the money thus obtained.

ÉTIENNE PASCAL took a great deal of interest in mathematical problems (it is after him that the algebraic curve known as the *limaçon of PASCAL* is named).



He participated regularly in the famous scientific discussions of the theologian, musicologist, and mathematician MARIN MERSENNE (1588–1648); however, he did not wish to burden his sickly son with mathematics – one reason was so that he would first master Latin and Greek – but finally, BLAISE began to pose geometric questions on his own, and the father could no longer keep his son away from mathematics.

Stimulated by the work of GIRARD DESARGUES (1591–1661), at age 16, BLAISE PASCAL presented a paper on conic sections to MERSENNE's group (*Essai pour les coniques*), which was later mentioned by GOTTFRIED WILHELM LEIBNIZ (1646–1716); unfortunately, this work has disappeared.

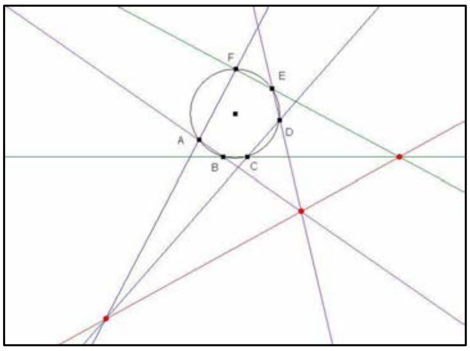
Triggered by the losses that the French state suffered on account of the *Thirty Years' War* (1618–1648), ÉTIENNE PASCAL's fortune decreased rapidly. In 1639, he took over the office of tax collector for Normandy. His son BLAISE developed a mechanical calculating machine to help with the tedious additions and subtractions involved in tax calculations. He improved on his model several times. Finally, *La Pascaline* was able to convert between the units of French currency (1 livre = 20 sols; 1 sol = 12 deniers), but it remained unreliable due to mechanical shortcomings.

Inspired by experiments carried out by EVANGELISTA TORRICELLI (1608–1647), BLAISE PASCAL undertook numerous experiments in the year 1646. He identified the law of hydrostatic equilibrium in fluids and the principle of communicating vessels; he demonstrated the decrease in air pressure with increasing height; and he proved the existence of a vacuum (*Traité de vide*), which had been tenaciously denied since the time of ARISTOTELE (*horror vacui*—nature abhors a vacuum). Despite the decisiveness of his results, such contemporaries as RENÉ DESCARTES remained unconvinced. Indeed, DESCARTES wrote polemically in a letter to CHRISTIAAN HUYGENS that PASCAL likely "had too much of a vacuum in his brain."

An event of 1646 fundamentally altered the life of the PASCAL family: Following a serious accident, the father remained for months under the care of physicians, whose success was more than medical: they converted the entire family to the Catholic reform movement known as *Jansenism*.

From this time forward, Blaise Pascal became deeply religious, though at first, he continued to work on mathematical problems. One of his sisters decided to enter the Jansenist convent Port-Royal, in Paris.

In 1647, Pascal turned once again to the subject of conic sections. One of his works contains, among other things, the following theorem:



- Pascal's theorem: If a hexagon has vertices A, B, C, D, E, F that are points lying on a conic section (here a circle), then the intersection points of each pair of opposite sides (that is, AB and DE, BC and EF, CD and AF) lie on a straight line.

Pascal showed that this theorem remains valid even when the points are not taken in alphabetical order.

The correspondence between Blaise Pascal and Pierre de Fermat (1608–1665) from 1654 – stimulated by Antoine Gombaud, Chevalier de Méré – is considered the origin of probability theory.

Pascal understood that one is more likely to roll at least one six on the throw of four dice (51.8%) than at least one double six in twenty-four throws of two dice (49.1%). This had seemed to him illogical (*l'arithmétique se démentoit*), since in each case, one was dealing with the same numeric relationship (4 to 6 and 24 to 36).

Fermat and Pascal discovered differing solutions to the following problem of Luca Pacioli: How should the wagers of two players be divided if a game has to be terminated prematurely?

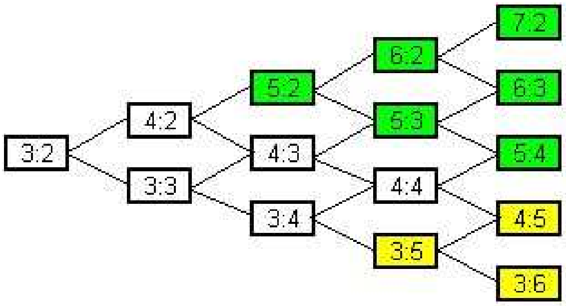
One of Pascal's solutions involved a recursive calculation of the odds of winning:

Suppose that a game requiring three points to win is broken off with the score at 2 points to 1. Then the first player would win the entire wager were he to win the next round, while if the second player won the next round, then the odds for the two players would have become equal. Therefore, altogether, the first player is three times more likely to have won than the second player. If the game was broken off at a score of 2 to 0, then the first player would have won the entire wager if he had won the next round. But if the second player had won the next round, then the score would have stood at 2 to 1, the odds for which have already been determined above. If the score was 1 to 0 when the game was terminated, then if the first player had won the next round, the score would have been 2 to 0, for which the odds have already been calculated, while if the second player had won, then their chances of winning would have been equal, and so on.

Another of Pascal's solutions relates to his intensive involvement with a special number triangle (*triangle arithmétique*). He showed that the correct distribution of the wager could be read off from this triangle.

Example: A game is interrupted with a score of 3 to 2 in a game in which the winner is the first to reach five points.

Solution idea: The game have ended after at most four additional rounds. The missing rounds are played out through a coin toss. In the graphic can be seen the four rounds, including those that take the game beyond completion, so that the coin toss was unnecessary. There are 1 + 4 + 6 paths leading to a win for the first player, while there are 4 + 1 paths leading to victory for the second player. Therefore, the wager is to be divided between the players in the proportion 11 to 5.



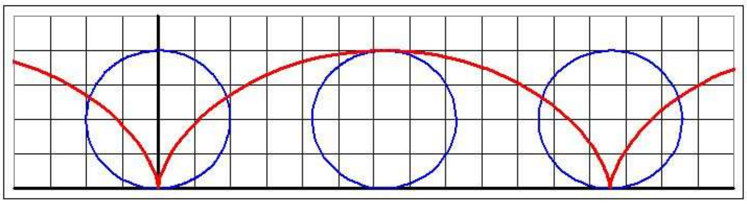
The "arithmetic" triangle that today is known as PASCAL's triangle was not, in fact, discovered by PASCAL. But he was the first to study deeply and prove properties of the binomial coefficients that the triangle encodes. In doing so, he used the technique of mathematical induction.

After a *mystical experience* in November 1656, PASCAL temporarily moved to the convent of *Port-Royal*, where he devoted himself to philosophical and theological questions. Under a pseudonym, he wrote polemics against the Jesuits (*Lettres provinciales*), which were rapidly disseminated despite a royal and ecclesiastical prohibition. They are considered by language specialists to represent the beginning of modern French prose on the basis of their brilliant composition.

Because of his rapidly deteriorating health, PASCAL was unable to finish an article on Christian faith (*Pensées sur la religion*). One of these pensées is the famous *PASCAL's wager*: belief in God is not only correct, but also rational, for if God did not exist, then one would lose nothing by believing in him; but if God does exist, then one loses everything if one does not believe.

His last mathematical work—written in a single night in the year 1658 when he couldn't sleep on account of the pain he was suffering – deals with cycloids, that is, curves that are the loci of a point on a rolling wheel. Such curves can be described by the following parametric equation:

$x(t) = r \cdot t - a \cdot \sin(t)$ and
$y(t) = r - a \cdot \cos(t)$



Not only was he able to calculate the arc length and area under the curve as well as the centroid, he also determined the volume of the solid generated by rotating the curve about the *x*-axis (here $a = r = 1$).

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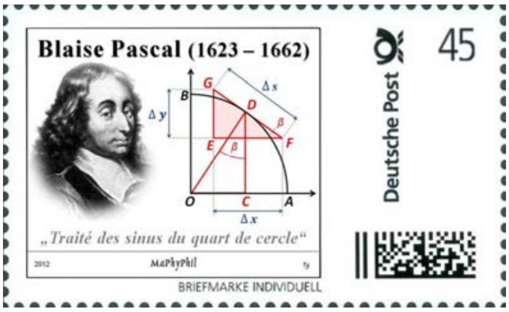

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