

# Pi, the Number Encyclopedia Article

## Pi, the Number

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# Pi, the Number

The number pi is the ratio of the circumference to the diameter of a circle. The use of pi among ancient civilizations played a significant role in geometry. It was often necessary to determine volumes of granaries and buildings, or areas of land. Problems involving divisions of fields or the number of bricks needed for some construction were readily converted into geometric problems. Among the earliest civilizations to use pi in these types of calculations was that of the Babylonians, who used the value 3, although in some cases a more accurate value of  $3 \frac{1}{8}$  was used as well. An Egyptian papyrus dating from 1700 B.C. shows that the Egyptians had already discovered a surprisingly reliable calculation for the area of a circle using the formula  $A = (8d/9)^2$ , where A is the area and d the diameter. This formula yields a value of approximately 3.1605 for pi.

However, it was unquestionably the Greeks of the period 500-100 B.C. who were the true masters of geometry and the approximation of pi. In *Measurements of a Circle*, the mathematician Archimedes worked with the circumferences of regular polygons, fixing the value of pi at less than  $3 \frac{1}{7}$  and greater than  $3 \frac{10}{71}$ . Some years later the Greek mathematician Apollonius of Perga improved on Archimedes' approximation of pi by using improved arithmetic methods.

Pi has been valuable in many types of formulas—geometric, algebraic, even statistical. In 1706 William Jones first utilized the symbol. While c and p were also used to represent pi, it was Leonhard Euler's 1748 book, *Introductio in analysin infinitorum*, that fixed as the permanent mathematical symbol for pi.

Johann Lambert proved that pi is an irrational number in 1761. In 1882, Carl Lindemann showed that pi is transcendental, that is, that pi is not the root of any polynomial with integer coefficients. The development of analytic methods also allowed energetic mathematicians to compute many digits of pi. In 1873, William Shanks published 707 digits of pi that he had computed after many years of labor using a formula involving the arctangent function. Unfortunately he made a mistake in the 528th digit, a fact that was not discovered until 1945. The use of computers has greatly reduced the tedium in calculating the digits of pi, and in June 1997 two Japanese mathematicians computed over 51.5 billion digits using 29 hours of computer time.