Handout

Source 1: The Decimal System and Zero

To make complex calculations the Hindus developed numerals and the decimal system, both of which came to the West through the Arabs, from India. (The English word cipher, meaning zero, is derived from the Arabic *Sifi*, which is a rendering of the original Sanskrit term *Sunya*, meaning empty.) The miscalled "Arabic" numerals are found on the Rock Edicts of Ashoka (256 B.C.E.), a thousand years before their occurrence in Arabic literature. Said the great mathematician Laplace:

> It is India that gave us the ingenious method of expressing all numbers by ten symbols, each receiving a value position as well as an absolute value; a profound and important idea, which appears so simple to us now that we ignore its true merit. But its very simplicity, the great ease which it has lent to all computations, puts our arithmetic in the first rank of useful inventions; and we shall appreciate the grandeur of this achievement the more when we remember that it escaped the genius of Archimedes and Apollonius, two of the greatest men produced in antiquity.

The decimal system was known to Aryabhata and Brahmagupta long before its appearance in the writings of the Arabs and the Syrians; it was adopted by China from Buddhist missionaries; and Muhammad Ibn Musa-al-Khwarazmi, the greatest mathematician of his age (d. ca 850 C.E.), seems to have introduced it into Baghdad. The oldest known use of the zero in Asia or Europe is in an Arabic document dated 873, three years sooner than its first known appearance in India; but by general consent the Arabs borrowed this too from India, and the most modest and most valuable of all numerals is one of the subtle gifts of India to mankind. [Will Durant. *The Story of Civilization*. New York: Simon and Schuster, 1954. p. 527]

Source 2: A.L. Basham comments on the importance of zero

The earliest inscription recording the date by a system of nine digits and a zero, with place notation for tens and hundreds, comes from Gujarat, and is dated A.D. 595. Soon after this the same notation had been heard of in Syria and was being used as far afield as Vietnam. Eventually the system was known to mathematicians some centuries before it was employed in inscriptions, the scribes of which tended to be conservative in their methods of recording dates… The name of the mathematician who devised this simplified system of writing numerals is unknown, but the earliest surviving mathematical texts—the anonymous "Bakshali Manuscript," which is a copy of a text of the fourth century A.D., and the terse *Aryahbatiya* of Aryabhata, written in A.D. 499—presupposes it…

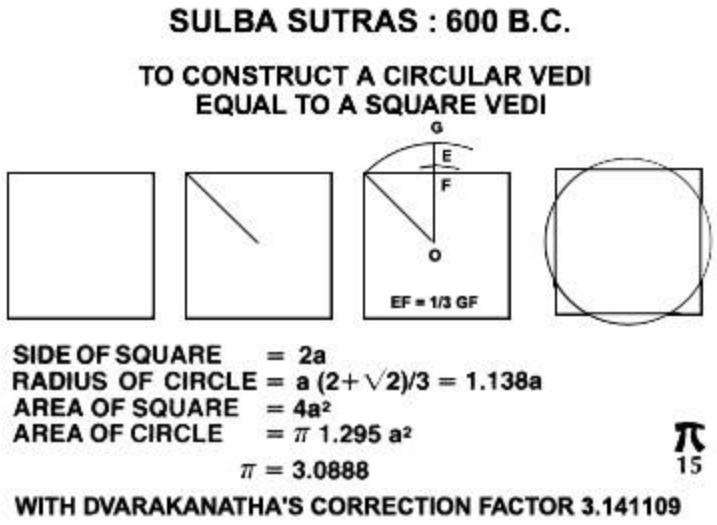
For long it was thought that the decimal system of numerals was invented by the Arabs, but this is certainly not the case. The Arabs themselves called mathematics "the Indian (art)" ["*hindisat*"], and it appears that the decimal notation, with other mathematical lore, was learnt by the Muslim world either through merchants trading with the west coast of India or through Arabs who conquered Sind in A.D. 712.

The debt of the Western world to India in this respect cannot be overestimated. Most of the great discoveries and inventions of which Europe is so proud would have been impossible without a developed system of mathematics, and this in turn would have been impossible if Europe had been shackled by the unwieldy system of Roman numerals. The unknown man who devised the new system was from the world's point of view, after the Buddha, the most important son of India. [A.L. Basham. *The Wonder that Was India*. New Delhi: Rupa & Co., 1994. 497-8.]

Source 3: What is the value of Pi?

The ancient Hindus were interested in performing ritual sacrifices on great outdoor altars. The altars they were required to construct were to have a circular shape but the same area as a square.

The Vedas gave a definite procedure for constructing these altars. From this, by inverse calculation, the Hindus obtained a low value of pi. The *Sullba Sutras*, written about 600 B.C.E., report on this process and give an estimate of pi as 3.141109.



Archimedes (287-212 BCE), perhaps the greatest mathematician and physicist of the ancient world, inscribed and circumscribed a circle with regular hexagons. He suggested pi fell between two limits that correspond to 3.140845 and 3.142857.

The Indian mathematician Aryabhata (476-550) published in 499 *Aryabhatiya*, in which he used the decimal point value system. He reported he had found the

value of pi to four figures—3.1416—but he did not say how he had figured this out.

Bhaskaracarya (1114-1185) was perhaps the greatest mathematician of his period. He devised an empirical formula for finding the length of a side of a regular polygon inscribed in a circle. He also devised the value of pi. Starting from a regular inscribed hexagon and from a similar figure of 384 sides, he figured out pi equals 3927 divided by 1250, or 3.1416**.**

Other important mathematicians working on pi included W. Brouncker (1620-1684), Newton (1643-1727), Leibniz (1646-1716), Maxhin (1680-1752) and Euler (1707-1783) who, by the way, adopted the Greek letter p to stand for pi. The Swiss mathematician J.H. Lambert (1728-1777) proved pi was an irrational number.

The other great Indian mathematician to work with pi was Srinivasa Ramanujan (b.1887), a self-taught genius whose first paper was "Modular Equation and Approximations to pi."

An Indian textbook adds: "Incidentally we like to cite the remarkable feat of an Indian mathematician Rajan Srinivasan Mahadevan who in 1991 continuously cited from memory the value of pi to over 31,800 places in 3 hours and 49 minutes." At the date of publication, the textbook authors reported he was preparing himself for 100,000 digits. They concluded, "This shows man's endeavors are always attempting newer heights and it is practically impossible to make a book of such venture that is up-to-date."

The same text also suggests ways to remember the value of pi. One strategy is to have numbers represent the letters of a particular word. For example, "may" has three letters, so in the statement it represents 3:

May I have a large container of coffee?
3 1 4 1 5 9 2 6

[The information in this source comes from a small Indian textbook, *Pi: An Unending Story in Mathematics*. New Delhi: National Council of Educational Research and Training, 1990.]