Zero: Much Ado About Nothing

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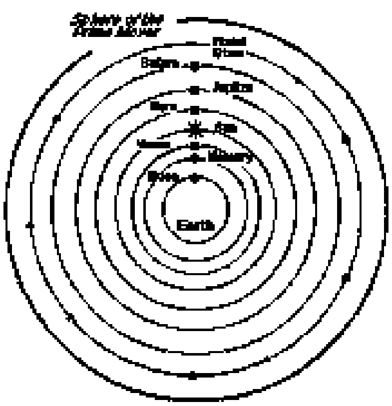
Journey with zero from its inception to the present day: Zero has been controversial since its invention by the Babylonians around 300 BC and later in the west by the Mayans about 300 AD. Zero threatened the foundations of Greek Philosophy, Calculus and the Big Bang theory. Eventually zero amassed defined properties and took its place among the other numbers.

The Babylonians developed a positional sexagesimal (base 60) system with zero representing a placeholder for missing powers on 60. The Babylonian symbol for zero is two small slanted wedges. Unlike the Babylonian  (placeholder) zero, the Mayan zero represents true zero. The symbol is  often described as a hole in the roof.

For the ancient Greeks numbers were largely geometric involving, area, volume, ratios, and optimal shapes like the golden rectangle. Zero didn't fit their definition of a number. For instance, Greek multiplication of two numbers yields an area. Of course when zero is one of these numbers the resulting area equals zero. Within this context they rejected zero. The Greeks preferred practical numeric concepts, geometrically descriptive and relatively logical.



Aristotle's Universe

Philosophically the Greeks viewed zero as a void tied to infinity. This is evident in the Ptolemaic view of the universe. The Ptolemaic view is based on a finite number of spinning spheres sequentially propelled by the outermost sphere. This view eliminated both infinity and the void and proved God's existence.

The word zero is traditionally linked to the Latin term *zephirum*, derived from the Arabic *sifr*, translated from the Hindu *sunya*, all meaning empty. Although zero has a long history, Muslim algebraists introduced it into the base ten-place value decimal system in the 12th century.

In 1202 Leonardo Fibonacci published *Liber Abaci*, introducing the

Muslim number system to Europe and launching the decline of Aristotelianism. *Liber Abaci* contained the Fibonacci sequence and the golden ratio but more importantly it introduced the base ten system. Zero and base ten were soon accepted among merchants, bankers and business but not with the local governments or the church. In 1299 the city of Florence banned zero and the Muslim system from fears of forgery such as a 3 being converted into an 8.

Zero allowed the place value system to dominate over symbolic systems and become one of mankind's greatest inventions. By 1400 belief in the Greek ideas were yielding to the new ideas of the Renaissance with zero leading the way. It is interesting to note that European mathematicians were among the last intellectuals to acknowledge zero.

Architecture and painting played an important role in zero's intellectual acceptance. In 1425 Italian architect Filippo Brunelleschi invented vanishing or zero point perspective drawing and later Leonardo diVinci published a guidebook for perspective drawing (1450). These developments helped usher in the great Renaissance period that revolutionized art, philosophy, theology, science and culture in general.

Of course the Pope and the Church challenged many of the revolutionary ideas notably the Copernicus solar system that placed the sun, not earth, at the center. Then around 1600 Galileo presented

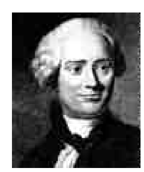
three public lectures and later a book arguing against Aristotelian theories. Unlike Copernicus, who published *De Revolutionibus* (1543) on his deathbed, Galileo's book *Dialogue* (1630) landed him a lifetime jail sentence. Galileo quickly published a retraction and the sentence was reduced to house arrest.

Finally, Blaise Pascal published *New Experiments Concerning the Vacuum*, in 1647. Working with Torricelli's notes on mercury filled tubes, Pascal solved the riddle of barometric pressure and showed that nature does not abhor a vacuum. The Mercury rises to 30 inches due to atmospheric pressure not due to avoidance of a vacuum.

Philosophically the battle for zero rested on Aristotle's assertion that nature abhors a vacuum. Rene Descartes found himself torn, he needed zero to anchor his coordinate system but due to his Jesuit beliefs he rejected the existence of any void. He also believed no thing traveled in a straight line because it would cause a trailing vacuum. He continually tried to reconcile the two opposing philosophies

Eventually Greek philosophy became part of the Christian doctrine and survived numerous challenges. During the reformation period, the Catholic Church came under intellectual attack. The Church responded with its own intellectuals, Aurelius Augustine and Thomas Aquinas.

Eighteenth century zero threatened the foundations of calculus in the form of Newton's ghosts. Newton solved the famous tangent line problem by taking a derivative. For a line through a point on a smooth curve Newton's *fluxion* method allowed Δx^2 to equal zero and Δx to be a divisor. Of course if Δx^2 were zero, then Δx would also equal zero and couldn't be a divisor. Newton overlooked zero as a notational anomaly because the fluxion method worked!



In 1745 Jean-Le-Rond D'Alembert proposed the theory of limits approaching zero to eliminate Newton's ghosts. Limits let infinitesimal quantities (Δx^2) be summed within the laws of arithmetic.

Of course zero also played a major role in physics.   William Thomson, better known as Lord Kelvin formalized the concept of absolute zero in the 1850's. Absolute zero is a theoretically possible yet unattainable state of matter with all energy dissipated. Although this state is not achievable in a laboratory, physicists get very close, similar to taking limits at zero.

Einstein's highly lauded Theory of General Relativity is based on a rubber sheet model of the universe. Zero punched holes into the space-time fabric and led to special relativity, the gravitational constant and Pauli's exclusion principle to patch the punctured continuum.

Additionally, Einstein assigned the center of a black hole to be zero, contributing to controversy surrounding the big bang theory. Zero threatened the idea of single point of collapsed matter exploding into a vacuum. The vacuum is now thought to be composed of infinite zero energy points that would cause the expanding matter to not be uniformly distributed.

Quantum mechanics has a somewhat similar problem with tiny particles and potential energy states that oscillate about zero. By describing these quantities as events that approach zero instead of equaling zero, the equations became reliable.

Mathematically a point has zero dimensions, a deficient description for a super small and highly dense clump of matter. String theory provides relief with tiny loops of nearly zero dimensions. An individual string or loop is essentially zero, but as strings accumulate and wind together dimensionality increases and symmetry results forming a Calabi-Yau space. The search for super symmetry or T-duality could yield equations that apply to both the big bang singularity and sub-atomic structures, based on dimensions that approach zero.

Although over-simplification reveals the similarity between quantum mechanics and the big bang theory, the connection between the two is not to be taken lightly. TOE or the theory of everything attempts to mathematically tie the very large to the very small based on the idea of a set of source equations from which other equations are derived. Currently, string theory comes closest to being a TOE but it is far from simple.

In depth study of zero eventually leads to infinity. Zero is a concept and a number, while infinity is a concept but not a number. The symbol infinity ∞ proposed in 1655 by John Wallis who wrote, "Infinity means more than any finite number assignable". George Cantor thoroughly researched infinity, which leads to another topic but provides a fitting end to this finite account of zero.