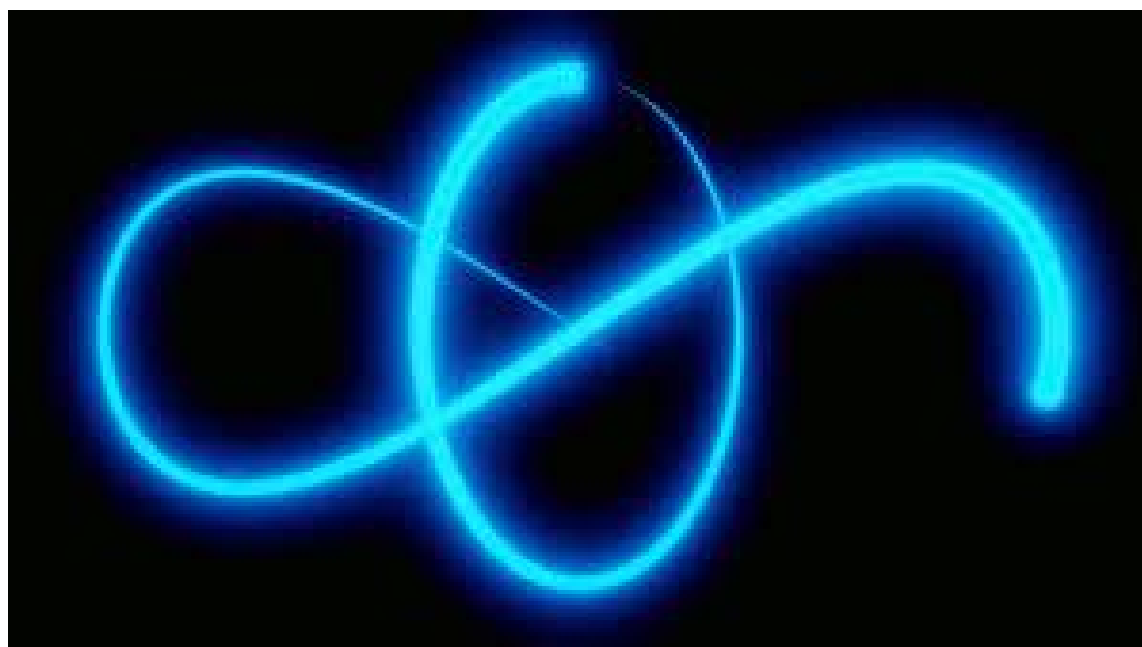


Nothing And Everything: The Strange Case of Zero and Infinity

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There are two which never fail to leave young learners or even experienced teachers confused. One of them doesn't exist. The other is too big to exist. And yet, without them, nothing works. For most of human history, zero was forbidden and infinity was a curse. We all have wondered once in our lives about “What comes before nothing?” or “What comes after Infinity?”. Two questions. Two apparent dead ends. And this is the story of how zero and infinity walked into mathematics and it has never been the same again.

Introduction:

What makes zero and infinity so fascinating isn't just their individual mystery, it's how they are reflections of each other. At the first glance they seem like opposites, nothing and everything. But in mathematics, opposites have a habit of secretly being the same thing. And zero and infinity are no exception. Two sides of the same coin. At various points in history, both were considered to be dangerous. Zero was a number people refused to acknowledge. While infinity was a concept people refused to approach. And yet here we are, with both of them sitting together quietly at the heart of calculus, physics and computing, holding everything together. Remove one of them, and the whole structural basis of Mathematics shatters. Far from dead ends, we now know zero and infinity are mathematics' greatest enablers, proving that embracing the impossible unlocks everything. To understand how this happened, we need to start from the beginning. Which is, fittingly, zero.

The History, Present and Future Of Zero:

The Past: Before zero was a number it was an absence ever present but never truly felt. And for a long time nobody thought an absence deserved to be counted. Therefore humanity invented words for one, two, ten, a thousand long before anyone thought to invent a word for nothing.

The Babylonians came the closest first. They used a small symbol as a placeholder, the way we might leave a blank space, but they never thought of it as a number you could actually do arithmetic with.

Then came the Greeks, who gave us so much of modern mathematics but famously wanted nothing to do with nothing. Aristotle argued that a true void was philosophically impossible. If something is empty, what is it filled with? The question felt like a trap, so they simply refused to open the door.

The breakthrough came in my country, India. Aryabhata was the first to acknowledge zero mathematically by introducing it as a placeholder in the decimal system. By the 7th century a mathematician named Brahmagupta did something nobody had done before. He wrote

down rules for calculating with zero. Add zero to a number and it stays the same. Subtract zero and nothing changes. Multiply by zero and everything becomes zero.

The Present: Today zero is everywhere. So embedded in our lives that its absence is almost unimaginable. In fact, we've built almost everything on top of it. Modern mathematics doesn't just tolerate zero, the basis of it is built completely upon it.

The Future: You might think zero's story is finished, that we've understood it, tamed it, and filed it away. But zero has a habit of showing up where it isn't supposed to and every time it does, something interesting follows. One of the world's greatest unsolved problems in all of mathematics is the Riemann Hypothesis, which fundamentally is a question about zero. Specifically, it asks where a particular function equals zero, and why those zeroes seem to line up so neatly. Zero, after all this time, is still not fully understood and holds a secret about the primes, which we haven't cracked yet. Zero began as a gap in a Babylonian counting system. It became a number, a foundation, a philosophical battleground, and now a living unsolved problem. For a number that represents nothing, zero has an awful lot going on.

What even is Infinity?

Infinity is not a number. Ask someone what infinity is and they will say "It goes on forever." Ask them what that means exactly, and the conversation gets interesting very quickly.

Infinity is one of those words everyone uses and almost nobody can define. It resides somewhere between mathematics and philosophy and it isn't entirely comfortable in either. Therefore the honest answer to "what is infinity" is that it depends entirely on who you ask. And the mathematical answer is considerably stranger than most people expect.

The Greeks once again were suspicious. Aristotle made a careful distinction that held for nearly two thousand years: you can count towards infinity, potential infinity, but you can never arrive there. Actual infinity, a completely endless thing was philosophically off-limits at that time.

The best way to feel why infinity is strange is through a humorous yet strange paradox posed by a Greek philosopher named Zeno roughly 2500 years ago. Achilles, the fastest runner in Greece, had agreed to race a tortoise and gave it a head start. But by the time Achilles reaches where the tortoise started, the tortoise has shuffled forward a little. By the time he reaches that point, it's moved again. This circle repeats forever. By this logic, Achilles never wins. And yet, in every race ever run, the faster runner wins. So what's going wrong? Zeno didn't have an answer. But he did have the question which cut through ages of mathematics.

Then came Georg Cantor. And he did something in the 1870s that nobody had seriously attempted before. He decided to measure infinity. Not just gesture at it, but actually

compare different infinities, rank them and prove which ones were bigger. Cantor's contemporaries at that time were not pleased. The mathematician Leopold Kronecker called him a 'corrupter of youth' and spent years trying to have his work suppressed. Henri Poincaré described Cantor's ideas as a 'grave disease' infecting mathematics. They were wrong. Within decades, Cantor's work would be considered the foundation of modern set theory. One of the most important contributions to mathematics in history. He was right. Mathematics eventually catches up.

Zero and Infinity. Two names, same anonymity:

Here is something that mathematics keeps trying to tell us, zero and infinity are not opposites. They are, in fact, partners. They go by different names. They live at different ends of the number line. But spend enough time with both of them and a pattern starts to emerge. Zero is nothing. Infinity is everything. And yet, mathematics cannot talk about one without invoking the other because each one makes the other possible. They are, in a sense, inverses of each other. Not in the technical sense of $1/x$, but in something deeper. Where one begins, the other ends. This is why dividing by zero is forbidden. It isn't arbitrary, it's because the answer would have to be infinity, and infinity isn't a number you can put in an equation and carry forward. The two concepts meet at that point and mathematics politely asks us to stop. When zero and infinity finally meet directly in an equation, mathematics does something unusual: it refuses to give a single answer. Expressions like $0 \times \infty$, or $\infty - \infty$, or $0/0$ are called indeterminate forms. They don't have a fixed value without more context. Two seemingly definite things produce something indefinite. They cancel each other's certainty. There is a construction in mathematics called the Riemann sphere that makes their relationship almost unbearably elegant. Take the entire infinite plane of complex numbers and wrap it around a sphere. Zero sits at the very bottom. Infinity sits at the very top. Two opposite poles, connected by the smooth surface of a single shape. Physics finds this partnership just as unavoidable as mathematics. At the centre of a black hole, general relativity predicts a singularity: density becomes infinite, volume shrinks to zero. The two extremes arrive simultaneously and the equations stop working. Our best theory of gravity meets its limit exactly where zero and infinity meet.

The Real World Dilemma:

Strip away the abstractions, and zero and infinity crash into our world with cosmic force. Picture a black hole: general relativity foretells a singularity, where matter crushes into zero volume at infinite density. Here, our equations shatter—physics' ultimate dead end,

where nothing and everything collide. Rewind to the Big Bang: the universe erupted from a similar point, birthing everything from apparent nothingness, a testament to how zero's void sparks creation.

Computers suffer daily with them. Divide by zero? Your program halts in error, a digital tantrum. Engineers devised the IEEE floating-point standard, tagging infinity as "Inf" to keep machines humming. A form of practical heroism against mathematical mischief. In quantum mechanics, calculations spew rogue infinities, like infinite self-energy in particle interactions.

Conclusion:

From forbidden placeholders to transfinite realms, zero and infinity have stormed mathematics, upending intuitions and enabling wonders. Once curses—zero as devilish void, infinity as divine overreach. They now remain as partners not opposites: mirrors in limits, saviors in singularities, guards against computational chaos. Yet their mystery endures. Does true infinity lurk in our finite universe? Can zero truly birth something? These questions are far from dead ends and fuel discovery. For young dreamers and seasoned thinkers alike, zero and infinity whisper math's deepest truth: the impossible isn't barren. And so, mathematics marches on, forever changed by its most enigmatic duo.