STEVEN HENRY STROGATZ

## Infinite Powers: How Calculus Reveals the Secrets of the Universe

New York: Houghton Mifflin Harcourt, First Mariner Books Edition 2020. 400 pages.

Steven Henry Strogatz, Applied Mathematics professor at Cornell University, is a staunch advocate of making math more accessible to the public by writing books, with *Infinite Powers: How Calculus Reveals the Secrets of the Universe* (2020) as his fourth work. Through his writing, he shows how math as a language helps us understand the world. Like other scientists, he stands on the shoulders of Galileo (1623 in Drake, 1957) who observed that:

> (Natural) philosophy is written in this grand book — I mean the Universe — which stands continually open to our gaze, but it cannot be understood unless one first learns to comprehend the language and interpret the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures, without which it is humanly impossible to understand a single word of it; without these, one is wandering around in a dark labyrinth. (pp. 237-8)

Strogatz builds on his previous works to allay the terrifying mystique of calculus as one more mathematical language. *Sync* (2003) illustrated math as one key to understanding the method behind the madness in the world, allowing us to sense internal order amidst the chaos of nature.

*Calculus of Friendship* (2009) revealed math as a language of love—forging a deep and intimate friendship between a student and his math teacher as they are united by a mutual appreciation for the language of calculus and enabling both to confront complex life issues such as pain, suffering and death, career change, and a broken marriage.

*The Joy of X* (2012), a subtle play on the title of a risqué 1970s book, used simple illustrations and formulas of basic arithmetic, geometry, and algebra to seductively offer the exhilarating gamut of mental and emotional pleasures afforded to anyone who engages intimately in the techniques of numerical intercourse.

The author appears to follow the natural cycle of life: hoping the child has grown up appreciating math and tasting its romance, what would this young

adult be searching for next? His intention for the book was "to make the greatest ideas and stories of calculus accessible to everyone" (vii) and builds this idea on an anecdote of a dialogue between the novelist Herman Wouk and the physicist Richard Feynman who one day asked Wouk if he knew calculus.

> "No," Wouk admitted, "I don't."
> "You had better learn it," said Feynman. "It's the language God talks."

It would then seem that Strogatz, like Galileo before him, was about to become a theologian, his fourth book showing how math could help in searching and finding God. Fortunately, Strogatz never made the same mistake Galileo did, gingerly avoiding the mistake of the giant of science, focusing on the subject at hand, but leaving enough intellectual guideposts for those wanting to take the search to the next level:

> For reasons nobody understands, the universe is deeply mathematical. Maybe God made it that way. Or maybe it's the only way a universe with us in it could be, because nonmathematical universes can't harbor life intelligent enough to ask the question. In any case, it's a mysterious and marvelous fact that our universe obeys laws of nature that always turn out to be expressible in the language of calculus as sentences called differential equations.
>
> Such equations describe the difference between something right now and the same thing an instant later, or between something right here and the same thing infinitesimally close by. The details differ depending on what part of nature we are talking about, but the structure of the laws is always the same. To put this awesome assertion another way, there seems to be something like a code to the universe, an operating system that animates everything from moment to moment and place to place. Calculus taps into this order and expresses it. (vii-viii)

Strogatz admits that his narration of calculus as the divine language is from the viewpoint of an applied mathematician—which he is—and not from that of a math historian, or a pure mathematician, or, if we may put it, a math theologian. Learning from the mistakes of mathematicians past, he knew how to stick to his field, walking on the edge certainly, but avoiding the dangerous minefield traversed by past and contemporary scientists-turned-theologians who use math to support atheistic views and cross the divide that is best kept separate and alone.

Just like Galileo before him, Strogatz the applied mathematician admitted his fascination with the push and pull between the real world and the ideal world as it appeared in the mind. Like countless scientists fluent in the language that remains a mystery for most of mankind, he discovered that "natural phenomena guide mathematical questions, and the math formulas that exist so clearly in the mind sometimes foreshadow what actually happens in reality… and when it does, the effect is uncanny."

Reading these portions of the Introduction would surely attract the curious reader, hoping to find answers to some questions gnawing at the back of the mind:

> *How did he prove that Calculus is the language that God speaks?*
> *How credible are his proofs?*
> *How did he make calculus accessible in a way that would satisfy Wouk who, unfortunately, passed on shortly after the book came out?*

Alas, this book is about calculus, not theology, so it does not give answers to these questions. Any reader expecting Strogatz to give answers to these questions would better be served by reading the book of Wouk, a practicing Jew, who was so smitten by Feynman's words that he wrote *The Language God Talks: On Science and Religion,* an account not of the linguistic theology of calculus but of Wouk's attempts to make his faith and the consequences of living it shine in his literature in a world that is ever growing faithless. Challenged by Feynman's words, Wouk caught a glimpse of a possible way to reconcile science and religion, as two beasts pulling the same cart in one direction.

Strogatz's book is not one such work. It is instead meant to make calculus comprehensible even to readers who have not taken up a single unit of calculus in school. The book was meant to elicit the same reaction as Wouk's to Feynman's challenge, which is to bring the discussion to the next level. However, for those familiar with calculus, philosophy, and the humanities, this book is an absolute delight. And for applied mathematicians who dream and eat calculus, this book would either be boring or, if they are not familiar with the side stories the author narrates, it would be entertaining.

He borrowed the Infinity Principle from Archimedes and explained it using slices of pizza. He showed how the speed of light could be calculated

(same root as calculus) by observing how butter melts in a microwave oven. Another fascinating story is about how calculus helped find a cure for AIDS.

Not all his stories are entertaining, however; more so when he spoke about the rivalries among the great minds of math, algebra, and calculus. Strogatz was kind to Fermat and brutal toward Descartes, short of calling him horrible names, but nevertheless painting him in an unkind light that would surely attract the wrath of Descartes' admirers. Other "rivalries" were highlighted in the book—Galileo and Kepler, Leibniz and Newton—but these were treated less harshly.

Lastly, Strogatz had one surprising titbit up his sleeve: it was while in isolation in a countryside farm house during the 17th century bubonic plague pandemic that Newton wrote down his formulas for calculus, motion in time and space, gravity, analytic geometry, and a few others. What scientific wonders await to be discovered during the pandemic we are now going through? Only time will tell.

The book is readable for non-academics; in fact, one could skip the formulas, glance at the illustrations, and focus on enjoying the stories. Learning the language of math is a productive way to spend these months of hiatus in intellectual bliss. With this latest oeuvre, Strogatz succeeds in demonstrating his dedication to his craft and his advocacy of making math beautiful, approachable, and lovable.

*Written on the 11th month of the Pandemic of 2020*

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**References**

Galilei, G. & Drake, S. (1957). Il Saggiatore (The Assayer). In Discoveries and Opinions of Galileo (pp. 237–238). essay, Doubleday & Co. Accessed on: https://www.princeton.edu/~hos/h291/assayer.htm and https://en.wikipedia.org/wiki/The_Assayer.

Strogatz, S. (2003). *Sync: How Order Emerges from Chaos in the Universe, Nature, and Daily Life*. Hyperion.

Strogatz, S. (2009). *The Calculus of Friendship: What a Teacher and a Student Learned about Life while Corresponding about Math*. Princeton University Press.

Strogatz, S. (2012). *The Joy of X: A Guided Tour of Math, from One to Infinity.* Houghton Mifflin.

Wouk, H. (2010). *The Language God Talks: On Science and Religion.* Little Brown.