Louis Nirenberg
(1925–2020)

Mathematician who transformed the study of partial differential equations.

After the Second World War, mathematics in the United States flourished owing to a convergence of interests. Mathematicians had shown their worth to military and industry patrons, who underwrote far-reaching empires of theories and people, including the consummate problem-solver Louis Nirenberg.

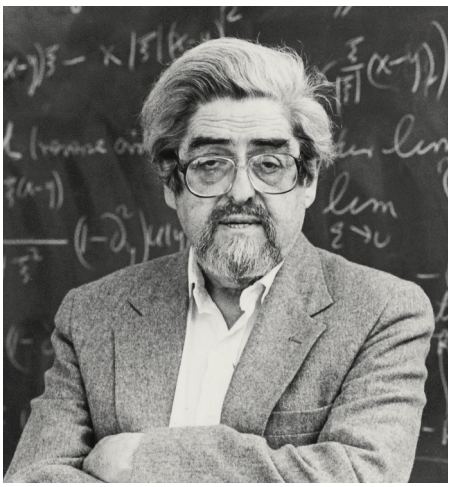
One of the world's most cited and productive mathematicians, Nirenberg was also among the most collaborative. His work continued to make waves until he was well into his eighties, and reshaped how mathematicians understand and study dynamical systems, from cells to markets. Winning the 2015 Abel Prize (shared with John Nash, made famous by the 2001 film *A Beautiful Mind*) was just a bookend to a fêted career. He died on 26 January, aged 94.

Nirenberg spent an illustrious seven decades at New York University (NYU), a realization of the discipline's post-war entanglements and their scholarly rewards. He joyfully nurtured people and ideas, skating above emerging distinctions between pure and applied mathematics.

Nirenberg transformed the field of partial differential equations (PDE), which explores what can be known about mathematical functions from studying how their variations along different dimensions relate to each other. Emerging from eighteenth-century mathematical physics, PDE became a centrepiece of a vast range of theoretical and applied subjects, from telecommunications and nuclear physics to debates about the nature of numbers. One famous and still-unresolved question in which Nirenberg's insights have been significant asks whether the equations governing the movement of water from a given initial state are always compatible with a smooth flow.

A virtuoso of approximation, Nirenberg was renowned for manipulating inequalities that govern the properties of unknown functions. Fellow mathematicians found his perspectives and methods strikingly lucid. His works catalysed large bodies of research, from general relativity to biology.

Raised in a Yiddish-speaking family in Montreal, Canada, Nirenberg acquired a taste for mathematical puzzles from his Hebrew tutor. After completing his undergraduate degree in mathematics and physics at McGill University in Montreal in 1945, Nirenberg joined his friend Sarah Courant at the nearby



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National Research Council, contributing to research on atomic weapons. On the advice of Sarah's father-in-law, Richard Courant, a leading mathematician at NYU, Nirenberg did a master's in mathematics at the university. He remained there for the rest of his career, heading the Courant Institute of Mathematical Sciences from 1970 to 1972.

Nirenberg trained with a who's who of twentieth-century mathematics, including his PhD supervisor James Stoker and his mentor Kurt Friedrichs as well as visiting scholars from across Europe, the Soviet Union and the Americas. With fellow students Peter Lax and Cathleen Morawetz, he climbed the ranks to professor.

Courant had courted federal contracts and support during the Second World War to lay the groundwork for his institute. Expansive budgets from sources including the Office of Naval Research supported Nirenberg's research on elliptic equations (with applications from fluid dynamics to finance) and pseudo-differential operators (a foundation for an enormous variety of approaches in modern physics). One-quarter of his publications, including his first four in 1953, were in the institute's own journal, *Communications on Pure and Applied Mathematics*.

Nirenberg considered the world's mathematicians to be "one big family", and found inspiration in visiting and hosting colleagues from around the world. His first extended overseas research trip, in 1951–52, took him to Zurich, Switzerland, where he wrote up results from his thesis and attended lectures from stars of Courant's generation. In 1963, he took part in a landmark symposium on PDE in Novosibirsk, which helped to redefine the relationship between the Soviet Union and the United States. There, he forged close friendships in an environment he compared to a voyage at sea. A later geopolitically significant trip took him to China toward the end of the Cultural Revolution. After being assigned a PhD thesis in Italian as the subject for a term paper during his graduate studies, he developed a lifelong affinity for Italy.

Nirenberg was known for using methods in their most fruitful generality. "I have made a living off the maximum principle," he quipped, referring to a fundamental technique for establishing inequalities in PDE. He demonstrated its versatile potential to researchers in many fields. As a young man, he had worried about his ability to formulate original problems. Yet Nirenberg gained a reputation for his exceptional insight and taste as a poser of problems that stretched the limits of research in mathematics and beyond.

His career awards included the first Crafoord Prize in 1982 and the first Chern Medal of the International Mathematical Union in 2010. Although he knew Nash, their Abel Prize recognized PDE work from separate parts of the firmament.

A famously congenial collaborator, Nirenberg co-authored papers to an extent unusual in mathematics. Some collaborations took place entirely by post, including the only work he published with his lifelong colleague Lax, conducted while Nirenberg was in Japan. Other collaborations — including with the 46 doctoral students he supervised — involved extended dialogues in front of a blackboard or while walking to a restaurant, as he digested new ideas in company.

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