Mathematicians A–Z

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Despite its often abstract nature, the study of mathematics is not divorced from the political, social, and historical forces that influence its investigators. Such influences may cause the achievements of individuals to not be fully recognised or appreciated within their lifetimes. Consequently, our understanding of what it means to be a "mathematician" can be biased.

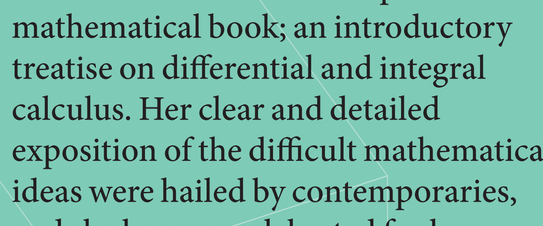
This poster series presents the life and work of 26 female & non-binary mathematicians, ordered alphabetically, who hail from backgrounds that are historically under-represented (or even prejudiced against) in the field but who nevertheless achieved great distinction, either within their own time or in recent years. Here we showcase their contributions to mathematics and its applications to the natural sciences. In doing so, we aim to bring more recognition to their accomplishments and inspire reflection on what it means to be a mathematician in contemporary society.

Maria Gaetana Agnesi
(Italy, 1718–1799)

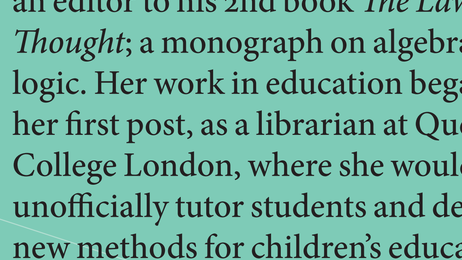
Born to a wealthy Milanese family, Maria Gaetana Agnesi was quickly recognised as a child prodigy and tutored by some of the leading Italian mathematicians of the era. In 1749 she became the first woman to publish a mathematical book; an introductory treatise on differential and integral calculus. Her clear and detailed exposition of the difficult mathematical ideas were hailed by contemporaries, and she became celebrated for her knowledge within the Holy Roman Empire. One year later, she was appointed to the chair of mathematics, natural philosophy & physics at the University of Bologna by Pope Benedict XIV, although she never served due to her father's deteriorating health and her own illnesses. A devout Catholic, she spent much of her life and family fortune on behalf of the sick, poor, and elderly of Milan.

Mary Everest Boole
(England, 1832–1916)

Mary Everest Boole was a largely self-taught mathematician, whose early education was complemented through her friendship with her future husband George Boole (English mathematician, 1815–1864). Indeed, Mary contributed as an editor to his 2nd book *The Laws of Thought*; a monograph on algebraic logic. Her work in education began at her first post, as a librarian at Queen's College London, where she would unofficially tutor students and develop new methods for children's education. She believed working with physical materials would strengthen a child's understanding of abstract mathematical concepts, and popularised creative methods of teaching (such as *curve stitching*, below) to realise this. She was the author of innovative pedagogical textbooks, publishing *Logic Taught by Love* in 1890, *The Preparation of the Child for Science* in 1904, and *Philosophy and Fun of Algebra* in 1909.



The Witch of Agnesi was analysed by Maria Gaetana Agnesi in 1749. It is constructed as follows: first, one draws a circle of radius $\frac{a}{2}$ that is tangent to the x-axis, passing through the origin. The x-coordinates of the *Witch* are located where a straight line from the origin intersects the line $y = a$, while its y-coordinates are where the same line intersects the circle. Equivalent to the graph $y = \frac{a^3}{a^2 + x^2}$, its English name derives from a mistranslation of the Italian word for a sailing sheet (*versiera*).



An example of a parabola created by stitching straight lines between points. The curve is the envelope of this family of lines.

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Poster sources Agnesi: Wikipedia, mathshistory.st-andrews.ac.uk. Boole: Wikipedia, darwinproject.ac.uk.

Image sources Agnesi: (top) Wikimedia Commons, (bottom) Engines of Our Ingenuity #1741, J.H. Lienhard. Boole: (top) CUL 300:2.c.95.12 (Cambridge University Library)

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Mathematicians
A–Z

Cartwright
Devi
Easley
Fawcett

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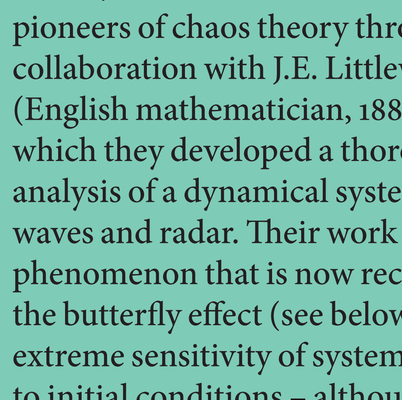
Mary Cartwright
(England, 1900–1998)

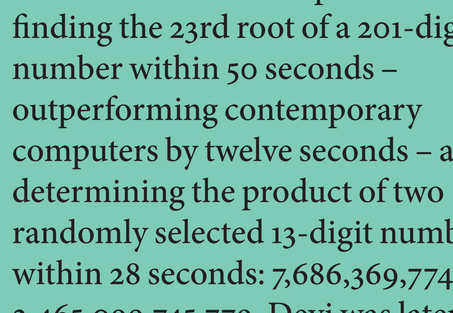
Born in Northamptonshire, Mary Cartwright completed her undergraduate and DPhil studies at Oxford. After completing her thesis on "The Zeros of Integral Functions of Special Types", she moved to Cambridge, staying there for the remainder of her career. During World War II, she became one of the early pioneers of chaos theory through a collaboration with J.E. Littlewood (English mathematician, 1885–1977) in which they developed a thorough analysis of a dynamical system for radio waves and radar. Their work described a phenomenon that is now recognised as the butterfly effect (see below) – an extreme sensitivity of system behaviour to initial conditions – although the significance of this work was not generally understood for another 20 years. A highly distinguished pure and applied mathematician, she was the first female mathematician elected Fellow of the Royal Society (in 1947) and also the first woman to serve on its council. In 1969 she became Dame Mary Cartwright, Dame Commander of the British Empire, after being honoured by Queen Elizabeth II.



Long exposure photograph of a light source fixed to the end of a double pendulum. This system is chaotic and exhibits the *butterfly effect*.

Shakuntala Devi
(India, 1929–2013)

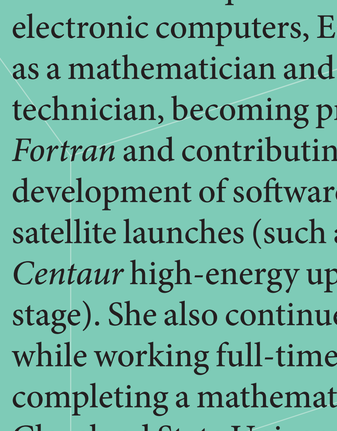
Shakuntala Devi was born in India to a family of circus performers. Although she did not have a formal education, she displayed a remarkable skill for mental arithmetic at the age of 3 and soon began performing at public road shows. Thanks to her talents, she became known as the "human computer". Two of her most famous exploits include finding the 23rd root of a 201-digit number within 50 seconds – outperforming contemporary computers by twelve seconds – and determining the product of two randomly selected 13-digit numbers within 28 seconds: 7,686,369,774,870 × 2,465,099,745,779. Devi was later inducted into the 1982 *Guinness Book of World Records* for this feat and her remarkable abilities. In 1977, she published one of the first academic studies of homosexuality within India in which she advocated for its decriminalisation and for acceptance of the community. She also achieved success as an astrologer, and was a prolific writer, publishing several collections of short stories, novels, cookbooks, and books on her mental calculation methods.



Shakuntala Devi performing calculations during a demonstration in New York in 1976.

Annie Easley
(USA, 1933–2011)

Annie Easley was a computer scientist, mathematician, rocket scientist, and one of the first African-American employees of NASA. Originally trained in pharmacy, she joined NACA (the predecessor of NASA) in 1955 as a "computer", performing long calculations by hand for researchers. With the subsequent introduction of electronic computers, Easley retrained as a mathematician and computer technician, becoming proficient in *Fortran* and contributing to the development of software for shuttle & satellite launches (such as for the *Centaur* high-energy upper rocket stage). She also continued her education while working full-time at NASA, completing a mathematics BSc. at Cleveland State University in 1977. Easley was known to be highly dedicated to outreach; she participated in school tutoring programmes and the Speaker's Bureau, educating about NASA's mission and inspiring female and minority students to consider STEM careers. In 2021, the International Astronomical Union named a crater on the Moon in her honour (*Easley*: 23.69°S, 87.97°E).



Easley at the NASA Lewis Research Center; cover of the *Science and Engineering Newsletter*, Vol. 5 No. 1, Spring 1982.

Philippa Fawcett
(England, 1868–1948)

Born in Cambridge, Philippa Fawcett achieved worldwide fame in 1890 when she became the first woman to obtain the top score in the University of Cambridge Mathematical Tripos Examinations (scoring 13% higher than the next best student). However, since men and women were not ranked together, she was denied the title of "Senior Wrangler" and was instead placed "above the Senior Wrangler". Her achievement spurred discussion about women's abilities and rights, and particularly influenced the contemporary women's suffrage movement in the UK. In 1902, Fawcett applied to the Transvaal Republic (now a South African state) for permission to set up an education system following the Second Boer War; once permission was granted, she was appointed lecturer in mathematics at the Normal School (a teacher training college) in Johannesburg. She remained there, setting up schools throughout the country, until 1905. Although she was denied her Cambridge degree because of her gender, Fawcett was one of the "steamboat ladies" who travelled to Ireland between 1904 & 1907 to receive an *ad eundem* degree from the University of Dublin.

The 1891 Newnham College Women's hockey team. Fawcett is seated front right in the photograph.

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Poster sources Cartwright: *Mary Cartwright*; Physics Today (2015) DOI:10.1063/PT.5.031114, BBC, mathshistory.st-andrews.ac.uk, Wikipedia. Devi: Wikipedia, the New York Times, *Shakuntala Devi*, Hinduism Today (2000), *Genius Shakuntala Devi mourned*, Eastern Eye London (2013). Easley: Wikipedia, NASA. Fawcett: Wikipedia, mathshistory.st-andrews.ac.uk.

Image sources Cartwright: (top) CC BY-SA 4.0, Victuallers/Wikimedia Commons, (bottom) CC BY-SA 4.0, Cristian V./Wikimedia Commons. Devi: (top) Barton Silverman/New York Times, (bottom) Vijay Mathur/Reuters. Easley: (top) NASA/Wikimedia Commons, (bottom) NASA/Wikimedia Commons. Fawcett: (top) *What I Remember* (1925), M.G. Fawcett. Wikimedia Commons, (bottom) mathshistory.st-andrews.ac.uk. (*Philippa Fawcett*, front right).

Mathematicians
A–Z

Germain
Hypatia
Ionel
Jackson

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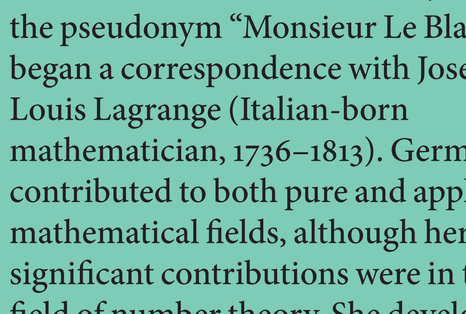
Sophie Germain
(France, 1776–1831)

Sophie Germain began studying mathematics at age 13, during the politically turbulent era of the French Revolution (1789–1801). Although barred from entering the École Polytechnique in 1794 (because of her gender), Germain nevertheless obtained mathematics lecture notes and, under the pseudonym "Monsieur Le Blanc", began a correspondence with Joseph-Louis Lagrange (Italian-born mathematician, 1736–1813). Germain contributed to both pure and applied mathematical fields, although her most significant contributions were in the field of number theory. She developed several novel approaches to proving *Fermat's Last Theorem* (see below) for general exponents *n*. Although she was unable to prove the full version of the theorem (and it would go unsolved for almost another 200 years), her work became a basis for later mathematicians attempting to solve this problem. Germain was also a pioneer of elasticity theory; in 1816 she won the *prix extraordinaire* from the Institut de France for her essay *Memoir on the Vibrations of Elastic Plates*.

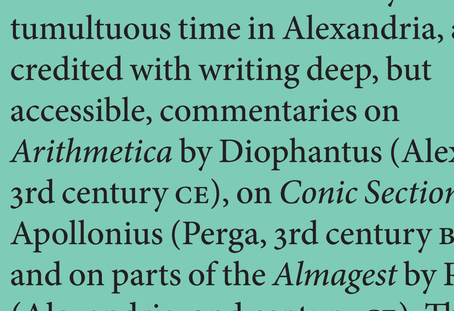


Fermat's Last Theorem: for all $n > 2$, the equation $x^n + y^n = z^n$ has no positive integer solutions x, y, z.

Originally stated c. 1637 by Pierre de Fermat (French mathematician, 1607–1665), the first successful proof was published in 1995 by Andrew Wiles (English mathematician, b. 1953).

Hypatia
(Alexandria, c. 350–370 CE – 415 CE)

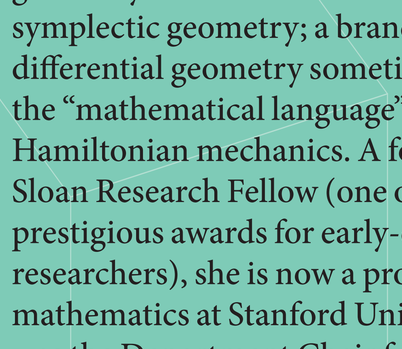
Hypatia of Alexandria is the earliest female mathematician whose life and work are reasonably well-documented. She was a Greek Neoplatonist philosopher, astronomer, and mathematician, renowned in her time as an efficacious lecturer at the Platonist school in Alexandria. Hypatia strove to preserve the heritage of Greek mathematics and astronomy during a tumultuous time in Alexandria, and is credited with writing deep, but accessible, commentaries on *Arithmetica* by Diophantus (Alexandria, 3rd century CE), on *Conic Sections* by Apollonius (Perga, 3rd century BCE), and on parts of the *Almagest* by Ptolemy (Alexandria, 2nd century CE). Though her original work is now lost, it is suspected her writings live on through the modern editions of these books. Outside of mathematics, Hypatia acted as an advisor to Orestes, the Roman prefect of Alexandria. She ultimately was drawn into a political feud between Orestes and Cyril, the Christian bishop of Alexandria, over which institution – the Church or the Roman state – would control the region. Caught in the middle, Hypatia was brutally murdered by a mob of Christian fanatics in 415 CE.



(Above) Artist's impression of the murder of Hypatia. Illustration by Louis Figuier, 1866. (Portrait) by Jules Maurice Gaspard, 1908.

Eleny Ionel
(Romania, b. 1969)

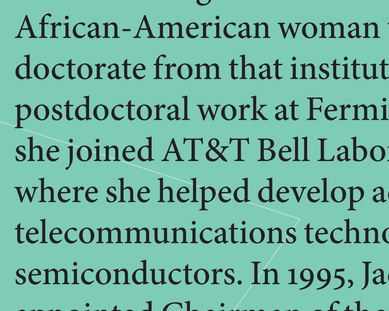
Born in Romania, Eleny Ionel was exposed at a young age to academic life through her family. After her undergraduate studies in Romania, she obtained a PhD at Michigan State University (USA), where she specialised in topics within the field of algebraic geometry. Her current interests involve symplectic geometry; a branch of differential geometry sometimes called the "mathematical language" for Hamiltonian mechanics. A former Sloan Research Fellow (one of the most prestigious awards for early-career researchers), she is now a professor of mathematics at Stanford University and was the Department Chair from 2016–2019. Ionel has authored a number of papers in the most distinguished modern mathematics journals, including *Annals of Mathematics*, *Inventiones mathematicae*, and the *Duke Mathematical Journal*. In recognition of her achievements, Ionel was named a Fellow of the American Mathematical Society in 2020 for "contributions to symplectic geometry and the geometric analysis approach to Gromov-Witten Theory".



Visualisation of the *Hopf fibration* in differential topology. The fibration is a useful method of mapping the four dimensional hypersphere into three dimensional space.

Shirley Ann Jackson
(USA, b. 1946)

Born in Washington D.C., Shirley Ann Jackson earned a B.S. in theoretical physics at MIT in 1968. During her undergraduate studies, Jackson advocated for outreach to students of colour and in 1968 co-founded the Black Students' Union. In 1973, she received a PhD in nuclear physics – also from MIT – and in doing so became the first African-American woman to earn a doctorate from that institution. After postdoctoral work at Fermilab & CERN, she joined AT&T Bell Laboratories where she helped develop advances in telecommunications technology and semiconductors. In 1995, Jackson was appointed Chairman of the US Nuclear Regulatory Commission (becoming both the first woman and first African-American to hold that position). There, she spearheaded the use of computer modelling for the management & assessment of risk in American nuclear power plants. In 2009, President Obama appointed Jackson to the President's Council of Advisors on Science and Technology. She was awarded the 2014 National Medal of Science in recognition of her contributions to physics & scientific public policy.



Jackson receiving the National Medal of Science from President Barack Obama in May 2016.

Poster sources Germain: Wikipedia, agnesscott.edu, *Sophie Germain: Revolutionary Mathematician* by Dora Musielak, Springer (2020). Hypatia: Wikipedia, mathshistory.st-andrews.ac.uk, britannica.com, *Hypatia: Life, Death, and Works* by Alan Cameron, in "Wandering Poets and Other Essays on Late Greek Literature and Philosophy", 2016. Ionel: Wikipedia, math.stanford.edu, ncatlab.org/nlab. Jackson: Wikipedia, MIT Technology Review: *The Remarkable Career of Shirley Ann Jackson* by Amanda Schaffer (2017), president.rpi.edu/president-biography.

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