

Princeton Mathematics

2023



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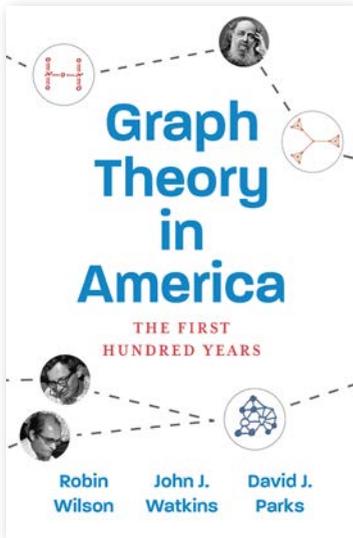
If you have publishing plans you would like to discuss, contact:

Diana Gillooly

Executive Editor, Mathematical Sciences

diana_gillooly@press.princeton.edu

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“This fascinating book documents the huge expansion in the range and depth of graph theory, from its first focus on the four color conjecture to the multifaceted subject it is today.”
—Peter Cameron, University of St. Andrews

How a new mathematical field grew and matured in America

Graph Theory in America

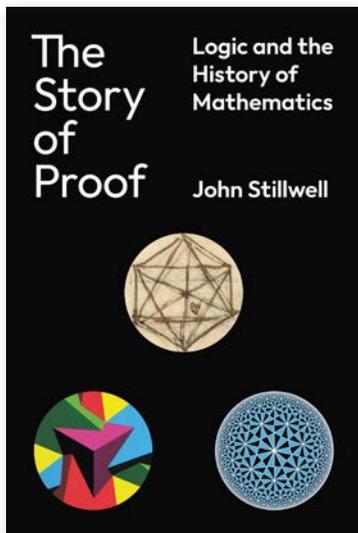
Graph Theory in America focuses on the development of graph theory in North America from 1876 to 1976. At the beginning of this period, James Joseph Sylvester, perhaps the finest mathematician in the English-speaking world, took up his appointment as the first professor of mathematics at the Johns Hopkins University, where his inaugural lecture outlined connections between graph theory, algebra, and chemistry—shortly after, he introduced the word *graph* in our modern sense. A hundred years later, in 1976, graph theory witnessed the solution of the long-standing four color problem by Kenneth Appel and Wolfgang Haken of the University of Illinois.

Tracing graph theory’s trajectory across its first century, this book looks at influential figures in the field, both familiar and less known. Whereas many of the featured mathematicians spent their entire careers working on problems in graph theory, a few such as Hassler Whitney started there and then moved to work in other areas. Others, such as C. S. Peirce, Oswald Veblen, and George Birkhoff, made excursions into graph theory while continuing their focus elsewhere. Between the main chapters, the book provides short contextual interludes, describing how the American university system developed and how graph theory was progressing in Europe. Brief summaries of specific publications that influenced the subject’s development are also included.

Graph Theory in America tells how a remarkable area of mathematics landed on American soil, took root, and flourished.

Robin Wilson is emeritus professor of mathematics at the Open University. His many books include *Four Colors Suffice* (Princeton). **John J. Watkins** is professor emeritus of mathematics at Colorado College. His books include *Topics in Commutative Graph Theory*, *Number Theory*, and *Across the Board* (all Princeton). **David J. Parks** received a PhD in mathematics at the Open University. His doctoral thesis forms the basis of this book.

January 2023. 320 pages. 147 b/w illus.
Hardback 9780691194028 \$35.00 | £30.00 ebook 9780691240657



“I am a great admirer of Stillwell’s writing, and this book does not disappoint. Ranging broadly and authoritatively over the history of mathematics, he takes the reader into those places where proofs have been innovative and have played a critical role.”

—David M. Bressoud, author of *Calculus Reordered*

How the concept of proof has enabled the creation of mathematical knowledge

The Story of Proof

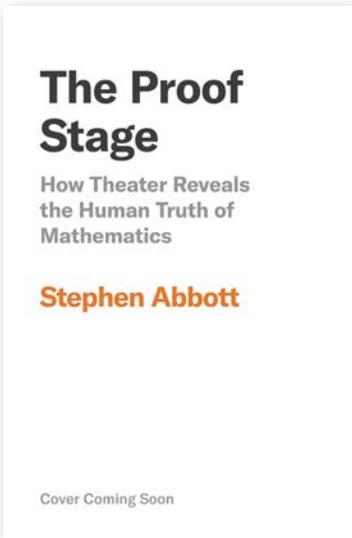
The Story of Proof investigates the evolution of the concept of proof—one of the most significant and defining features of mathematical thought—through critical episodes in its history. From the Pythagorean theorem to modern times, and across all major mathematical disciplines, John Stillwell demonstrates that proof is a mathematically vital concept, inspiring innovation and playing a critical role in generating knowledge.

Stillwell begins with Euclid and his influence on the development of geometry and its methods of proof, followed by algebra, which began as a self-contained discipline but later came to rival geometry in its mathematical impact. In particular, the infinite processes of calculus were at first viewed as “infinitesimal algebra,” and calculus became an arena for algebraic, computational proofs rather than axiomatic proofs in the style of Euclid. Stillwell proceeds to the areas of number theory, non-Euclidean geometry, topology, and logic, and peers into the deep chasm between natural number arithmetic and the real numbers. In its depths, Cantor, Gödel, Turing, and others found that the concept of proof is ultimately part of arithmetic. This startling fact imposes fundamental limits on what theorems can be proved and what problems can be solved.

Shedding light on the workings of mathematics at its most fundamental levels, *The Story of Proof* offers a compelling new perspective on the field’s power and progress.

John Stillwell is emeritus professor of mathematics at the University of San Francisco. His many books include *Elements of Mathematics* and *Reverse Mathematics* (both Princeton).

November 2022. 456 pages. 98 color + 71 b/w illus.
Hardback 9780691234366 \$45.00 | £38.00 ebook 9780691234373



How playwrights from Alfred Jarry and Samuel Beckett to Tom Stoppard and Simon McBurney brought the power of abstract mathematics to the human stage

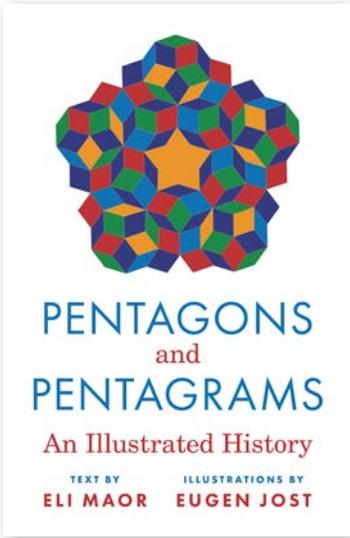
The Proof Stage

The discovery of alternate geometries, paradoxes of the infinite, incompleteness, and chaos theory revealed that, despite its reputation for certainty, mathematical truth is not immutable, perfect, or even perfectible. Beginning in the last century, a handful of adventurous playwrights took inspiration from the fractures of modern mathematics to expand their own artistic boundaries. Originating in the early avant-garde, mathematics-infused theater reached a popular apex in Tom Stoppard's 1993 play *Arcadia*. In *The Proof Stage*, mathematician Stephen Abbott explores this unlikely collaboration of theater and mathematics. He probes the impact of mathematics on such influential writers as Alfred Jarry, Samuel Beckett, Bertolt Brecht, and Stoppard, and delves into the life and mathematics of Alan Turing as they are rendered onstage. The result is an unexpected story about the mutually illuminating relationship between proofs and plays—from Euclid and Euripides to Gödel and Godot.

Theater is uniquely poised to discover the soulful, human truths embedded in the austere theorems of mathematics, but this is a difficult feat. It took Stoppard twenty-five years of experimenting with the creative possibilities of mathematics before he succeeded in making fractal geometry and chaos theory integral to *Arcadia*'s emotional arc. In addition to charting Stoppard's journey, Abbott examines the post-*Arcadia* wave of ambitious works by Michael Frayn, David Auburn, Simon McBurney, Snoo Wilson, John Mighton, and others. Collectively, these gifted playwrights transform the great philosophical upheavals of mathematics into profound and sometimes poignant revelations about the human journey.

Stephen Abbott is professor of mathematics at Middlebury College, where he has been teaching for thirty years. He is the author of the widely used textbook *Understanding Analysis* and theater events chair for the Bridges Organization, a professional association dedicated to exploring the intersection of mathematics and art.

July 2023. 320 pages. 15 color + 82 b/w illus.
Hardback 9780691206080 \$35.00 | £30.00 ebook 9780691243368



“Eli Maor expertly weaves together the mathematics, history, and cultural uses of pentagons and pentagrams—shapes that have fascinated us for more than two millennia. Beautifully complemented by Eugen Jost’s illustrations, this book delights and informs.”

—Ian Stewart, author of *What’s the Use?: How Mathematics Shapes Everyday Life*

A fascinating exploration of the pentagon and its role in various cultures

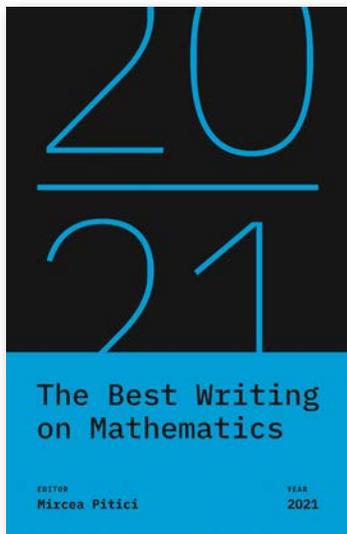
Pentagons and Pentagrams

The pentagon and its close cousin, the pentagram, have inspired individuals for the last two and half millennia, from mathematicians and philosophers to artists and naturalists. Despite the pentagon’s wide-ranging history, no single book has explored the important role of this shape in various cultures, until now. Richly illustrated, *Pentagons and Pentagrams* offers a sweeping view of the five-sided polygon, revealing its intriguing geometric properties and its essential influence on a variety of fields.

Traversing time, Eli Maor narrates vivid stories, both celebrated and unknown, about the pentagon and pentagram. He discusses the early Pythagoreans, who ascribed to the pentagon mythical attributes, adopted it as their emblem, and figured out its construction with a straightedge and compass. Maor looks at how a San Diego housewife uncovered four previously unknown types of pentagonal tilings, and how in 1982 a scientist’s discovery of fivefold symmetries in certain alloys caused an uproar in crystallography and led to a Nobel Prize. Maor also discusses the pentagon’s impact on many buildings, from medieval fortresses to the Pentagon in Washington, D.C. Eugen Jost’s superb illustrations provide sumptuous visual context, and the book’s puzzles and mazes offer fun challenges for readers, with solutions given in an appendix.

Eli Maor is a former professor of the history of mathematics at Loyola University Chicago. His books include the internationally acclaimed *To Infinity and Beyond*, *e: The Story of a Number*, *The Pythagorean Theorem: A 4,000-Year History*, *Music by the Numbers*, and with Eugen Jost, *Beautiful Geometry* (all Princeton). **Eugen Jost** is a well-known Swiss artist whose work is strongly influenced by mathematics.

2022. 200 pages. 19 color + 85 b/w illus.
 Hardback 9780691201122 \$24.95 | £20.00 ebook 9780691238555



“A variety of thoroughly accessible works that tie abstract math to the real world. . . . Gives readers an entertaining look at the odd, the amusing, and the utilitarian without requiring any more than a readerly curiosity.”

—*Publishers Weekly*

The year’s finest mathematical writing from around the world

The Best Writing on Mathematics 2021

This annual anthology brings together the year’s finest mathematics writing from around the world—and you don’t need to be a mathematician to enjoy the pieces collected here. These essays—from leading names and fresh new voices—delve into the history, philosophy, teaching, and everyday aspects of math, offering surprising insights into its nature, meaning, and practice, and taking readers behind the scenes of today’s hottest mathematical debates.

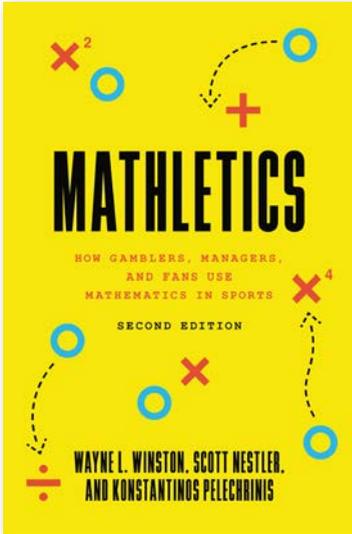
Here, Viktor Blåsjö gives a brief history of “lockdown mathematics”; Yelda Nasifoglu decodes the politics of a seventeenth-century play in which the characters are geometric shapes; and Andrew Lewis-Pye explains the basic algorithmic rules and computational procedures behind cryptocurrencies. In other essays, Terence Tao candidly recalls the adventures and misadventures of growing up to become a leading mathematician; Natalie Wolchover shows how old math gives new clues about whether time really flows; and David Hand discusses the problem of “dark data”—information that is missing or ignored. And there is much, much more.

Mircea Pitici teaches mathematics at Syracuse University and has edited *The Best Writing on Mathematics* since 2010.

2022. 320 pages. 16 color + 91 b/w illus.

Hardback 9780691225715 \$85.00 | £70.00

Paperback 9780691225708 \$24.95 | £20.00 ebook 9780691225722



“If you are looking for the best way to understand sports analytics, *Mathletics* is the book for you. You don’t have to be a math guru to benefit from *Mathletics*, you just have to love sports. This should be required reading for everyone looking to work in the front office in any sport.”

—Mark Cuban, owner of the Dallas Mavericks

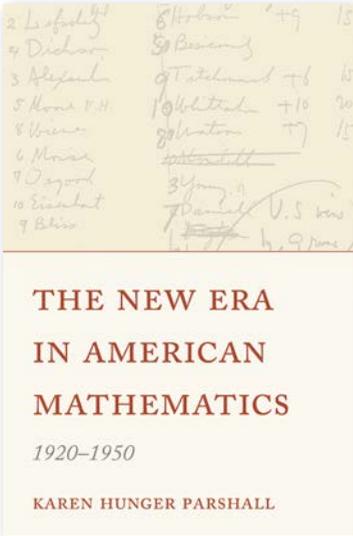
How to use math to improve performance and predict outcomes in professional sports

Mathletics

Mathletics reveals the mathematical methods top coaches and managers use to evaluate players and improve team performance, and gives math enthusiasts the practical skills they need to enhance their understanding and enjoyment of their favorite sports—and maybe even gain the outside edge to winning bets. This second edition features new data, new players and teams, and new chapters on soccer, e-sports, golf, volleyball, gambling Calcuttas, analysis of camera data, Bayesian inference, ridge regression, and other statistical techniques. After reading *Mathletics*, you will understand why baseball teams should almost never bunt; why football overtime systems are unfair; why points, rebounds, and assists aren’t enough to determine who’s the NBA’s best player; and more.

Wayne L. Winston is the John and Esther Reese Professor of Decision Sciences at Indiana University’s Kelley School of Business. **Scott Nestler** is associate teaching professor at the University of Notre Dame’s Mendoza College of Business. **Konstantinos Pelechrinis** is associate professor at the University of Pittsburgh’s School of Computing and Information.

2022. 608 pages. 197 line illus. 55 tables.
Paperback 9780691177625 \$24.95 | £20.00 ebook 9780691189291



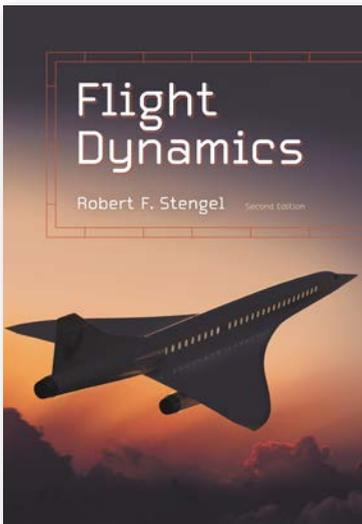
A meticulously researched history on the development of American mathematics in the three decades following World War I

The New Era in American Mathematics, 1920–1950

As the Roaring Twenties lurched into the Great Depression, American mathematicians pursued their research, positioned themselves collectively within American science, and rose to global mathematical hegemony. How did they do it? *The New Era in American Mathematics, 1920–1950* explores the institutional, financial, social, and political forces that shaped and supported this community in the first half of the twentieth century.

Karen Hunger Parshall is the Commonwealth Professor of History and Mathematics at the University of Virginia.

2022. 640 pages. 38 b/w illus.
 Hardback 9780691197555 \$130.00 | £109.00
 Paperback 9780691235240 \$49.95 | £42.00 ebook 9780691233819



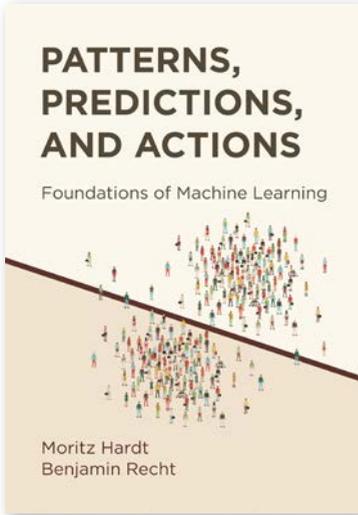
An updated and expanded new edition of an authoritative book on flight dynamics and control system design for all types of current and future fixed-wing aircraft

Flight Dynamics

Since it was first published, *Flight Dynamics* has offered a new approach to the science and mathematics of aircraft flight, unifying principles of aeronautics with contemporary systems analysis. Now updated and expanded, this authoritative book by award-winning aeronautics engineer Robert Stengel presents traditional material in the context of modern computational tools and multivariable methods. Special attention is devoted to models and techniques for analysis, simulation, evaluation of flying qualities, and robust control system design.

Robert F. Stengel is professor emeritus of mechanical and aerospace engineering and former associate dean of engineering and applied science at Princeton University.

November 2022. 912 pages. 527 b/w illus. 39 tables.
 Hardback 9780691220253 \$150.00 | £125.00 ebook 9780691237046



“This modern treatment of machine learning is notable for its coverage of emerging, important topics, from datasets and deep learning to optimization, causal inference, and social context, along the way pointing out the attendant perils that come from flawed predictions.”

—David C. Parkes, Harvard University

An authoritative, up-to-date graduate textbook on machine learning that highlights its historical context and societal impacts

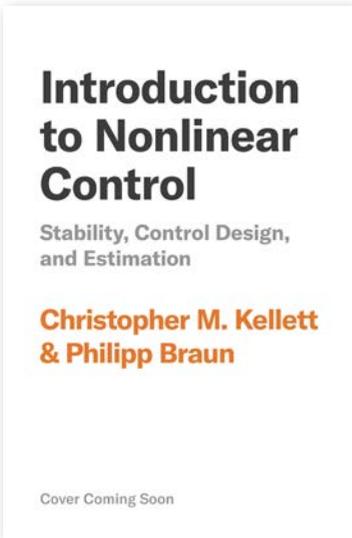
Patterns, Predictions, and Actions

Patterns, Predictions, and Actions introduces graduate students to the essentials of machine learning while offering invaluable perspective on its history and social implications. Beginning with the foundations of decision making, Moritz Hardt and Benjamin Recht explain how representation, optimization, and generalization are the constituents of supervised learning. They go on to provide self-contained discussions of causality, the practice of causal inference, sequential decision making, and reinforcement learning, equipping readers with the concepts and tools they need to assess the consequences that may arise from acting on statistical decisions.

- Provides a modern introduction to machine learning, showing how data patterns support predictions and consequential actions
- Pays special attention to societal impacts and fairness in decision making
- Traces the development of machine learning from its origins to today
- Features a novel chapter on machine learning benchmarks and datasets
- Invites readers from all backgrounds, requiring some experience with probability, calculus, and linear algebra
- An essential textbook for students and a guide for researchers

Moritz Hardt is a director at the Max Planck Institute for Intelligent Systems. **Benjamin Recht** is professor of electrical engineering and computer sciences at the University of California, Berkeley.

2022. 320 pages. 41 b/w illus. 10 tables.
 Hardback 9780691233734 \$55.00 | £45.00 ebook 9780691233727



An introductory text on the analysis, control, and estimation of nonlinear systems, appropriate for advanced undergraduate and graduate students

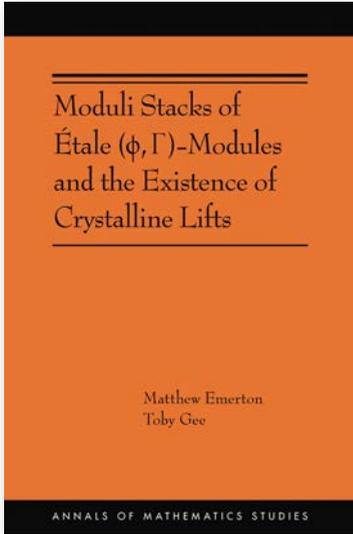
Introduction to Nonlinear Control

This self-contained and accessible introduction to the concepts and techniques used for nonlinear feedback systems offers a holistic treatment suitable for use in both advanced undergraduate and graduate courses; students need only some familiarity with differential equations and linear algebra to understand the material presented. The text begins with an overview of stability and Lyapunov methods for nonlinear systems, with Lyapunov's second method revisited throughout the book as a connective thread. Other introductory chapters cover linear systems, frequency domain methods, and discrete-time systems. Building on this background material, the book provides a broad introduction to the basic ideas underpinning major themes of research in nonlinear control, including input-to-state stability, sliding mode control, adaptive control, feedback linearization, and robust output regulation.

- First text on nonlinear control appropriate for undergraduates
- Suitable both for students preparing for rigorous graduate study and for those entering technical fields outside of academia
- Unique in its coverage of recent research topics
- Pedagogical features including extensive chapter summaries, examples, and appendices with definitions, results, and MATLAB applications

Christopher M. Kellett is professor of engineering at the Australian National University where he is director of the School of Engineering. **Philipp Braun** is a senior lecturer in the School of Engineering at the Australian National University.

June 2023. 552 pages. 166 b/w illus. 2 tables.
 Hardback 9780691240480 \$90.00 | £75.00 ebook 9780691240497



A foundational account of a new construction in the p -adic Langlands correspondence

Moduli Stacks of Étale (ϕ, Γ) -Modules and the Existence of Crystalline Lifts

Motivated by the p -adic Langlands program, this book constructs stacks that algebraize Mazur's formal deformation rings of local Galois representations. More precisely, it constructs Noetherian formal algebraic stacks over $\mathrm{Spf} \mathbb{Z}_p$ that parameterize étale (ϕ, Γ) -modules; the formal completions of these stacks at points in their special fibres recover the universal deformation rings of local Galois representations. These stacks are then used to show that all mod p representations of the absolute Galois group of a p -adic local field lift to characteristic zero, and indeed admit crystalline lifts. The book explicitly describes the irreducible components of the underlying reduced substacks and discusses the relationship between the geometry of these stacks and the Breuil–Mézard conjecture. Along the way, it proves a number of foundational results in p -adic Hodge theory that may be of independent interest.

Matthew Emerton is professor of mathematics at the University of Chicago. **Toby Gee** is professor of mathematics at Imperial College London.

December 2022. 312 pages.

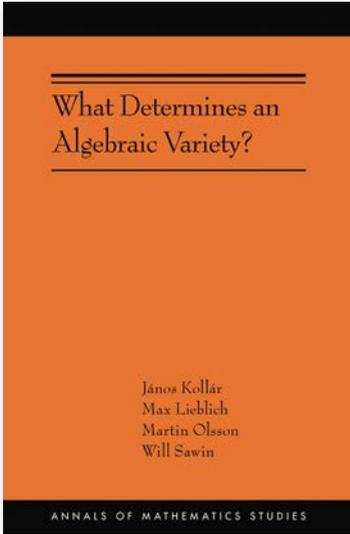
Hardback 9780691241340

\$180.00 | £150.00

Paperback 9780691241357

\$85.00 | £70.00

ebook 9780691241364



A pioneering new nonlinear approach to a fundamental question in algebraic geometry

What Determines an Algebraic Variety?

One of the crowning achievements of nineteenth-century mathematics was the proof that the geometry of lines in space uniquely determines the Cartesian coordinates, up to a linear ambiguity. *What Determines an Algebraic Variety?* develops a nonlinear version of this theory, offering the first nonlinear generalization of the seminal work of Veblen and Young in a century. While the book uses cutting-edge techniques, the statements of its theorems would have been understandable a century ago; despite this, the results are totally unexpected. Putting geometry first in algebraic geometry, the book provides a new perspective on a classical theorem of fundamental importance to a wide range of fields in mathematics.

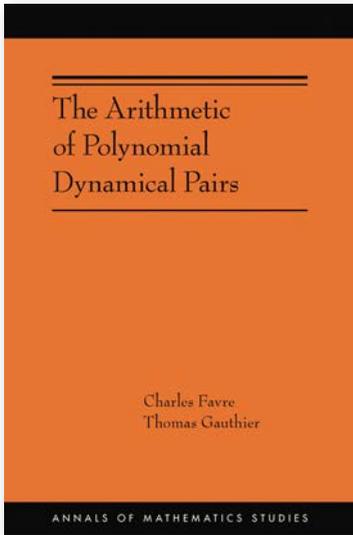
Starting with basic observations, the book shows how to read off various properties of a variety from its geometry. The results get stronger as the dimension increases. The main result then says that a normal projective variety of dimension at least 4 over a field of characteristic 0 is completely determined by its Zariski topological space. There are many open questions in dimensions 2 and 3, and in positive characteristic.

János Kollár is professor of mathematics at Princeton University and the author of eight books on algebraic geometry, including *Lectures on Resolution of Singularities* (Princeton). **Max Lieblich** is the Craig McKibben and Sarah Merner Endowed Professor of Mathematics at the University of Washington, Seattle. **Will Sawin** is assistant professor of mathematics at Columbia University. **Martin Olsson** is professor of mathematics at the University of California, Berkeley.

July 2023. 240 pages. 4 b/w illus.

Hardback 9780691246802 \$165.00 | £138.00

Paperback 9780691246819 \$75.00 | £62.00 ebook 9780691246833



New mathematical research in arithmetic dynamics

The Arithmetic of Polynomial Dynamical Pairs

In *The Arithmetic of Polynomial Dynamical Pairs*, Charles Favre and Thomas Gauthier present new mathematical research in the field of arithmetic dynamics. Specifically, the authors study one-dimensional algebraic families of pairs given by a polynomial with a marked point. Combining tools from arithmetic geometry and holomorphic dynamics, they prove an “unlikely intersection” statement for such pairs, thereby demonstrating strong rigidity features for them. They further describe one-dimensional families in the moduli space of polynomials containing infinitely many postcritically finite parameters, proving the dynamical André-Oort conjecture for curves in this context, originally stated by Baker and DeMarco.

This is a reader-friendly invitation to a new and exciting research area that brings together sophisticated tools from many branches of mathematics.

Charles Favre is a CNRS senior researcher based at the École Polytechnique in Paris. He is the coauthor of *The Valuative Tree* and the coeditor of *Berkovich Spaces and Applications*. **Thomas Gauthier** is professor of mathematics at the Université Paris-Saclay.

2022. 252 pages. 18 b/w illus.

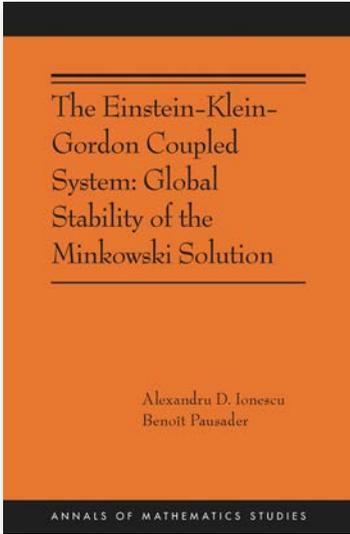
Hardback 9780691235462

\$165.00 | £138.00

Paperback 9780691235479

\$75.00 | £62.00

ebook 9780691235486



The Einstein-Klein-Gordon Coupled System

This book provides a definitive proof of global nonlinear stability of Minkowski space-time as a solution of the Einstein-Klein-Gordon equations of general relativity. Along the way, a novel robust analytical framework is developed, which extends to more general matter models. Alexandru Ionescu and Benoît Pausader prove global regularity at an appropriate level of generality of the initial data, and then prove several important asymptotic properties of the resulting space-time, such as future geodesic completeness, peeling estimates of the Riemann curvature tensor, conservation laws for the ADM tensor, and Bondi energy identities and inequalities.

Alexandru D. Ionescu is professor of mathematics at Princeton University. **Benoît Pausader** is professor of mathematics at Brown University.

2022. 308 pages.

Hardback 9780691233055 \$165.00 | £138.00

Paperback 9780691233048 \$75.00 | £62.00 ebook 9780691233031

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Annals of Mathematics Journal

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Associate Editors: Ian Agol, Frank Calegari, Jacob Fox, Alex Lubotzky, Russell Lyons, William Minicozzi, Pham Huu Tiep

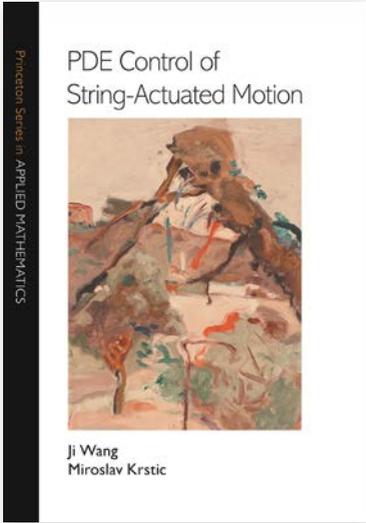
Founded in 1884, this distinguished bimonthly journal of research papers in mathematics is published by the Department of Mathematics of Princeton University with the cooperation of the Institute for Advanced Study.

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New adaptive and event-triggered control designs with concrete applications in undersea construction, offshore drilling, and cable elevators

PDE Control of String-Actuated Motion

Control applications in undersea construction, cable elevators, and offshore drilling present major methodological challenges because they involve PDE systems (cables and drillstrings) of time-varying length, coupled with ODE systems (the attached loads or tools) that usually have unknown parameters and unmeasured states. In *PDE Control of String-Actuated Motion*, Ji Wang and Miroslav Krstic develop control algorithms for these complex PDE-ODE systems evolving on time-varying domains.

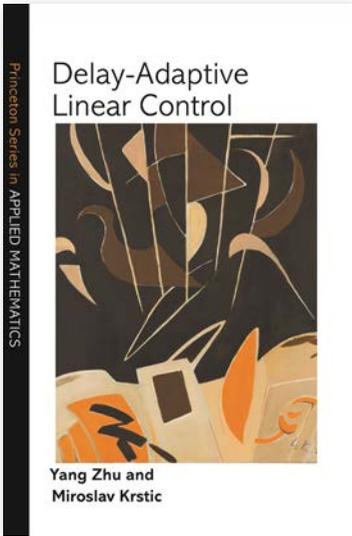
Motivated by physical systems, the book’s algorithms are designed to operate, with rigorous mathematical guarantees, in the presence of real-world challenges, such as unknown parameters, unmeasured distributed states, environmental disturbances, delays, and event-triggered implementations. The book leverages the power of the PDE backstepping approach and expands its scope in many directions.

Filled with theoretical innovations and comprehensive in its coverage, *PDE Control of String-Actuated Motion* provides new design tools and mathematical techniques with far-reaching potential in adaptive control, delay systems, and event-triggered control.

Ji Wang is associate professor in the Department of Automation at Xiamen University, China, and a former postdoctoral scholar at the University of California, San Diego. **Miroslav Krstic** is Distinguished Professor at the University of California, San Diego, where he also serves as senior associate vice chancellor for research. He is a recipient of the Bellman, Reid, and Oldenburger awards, and is the coauthor of many books, including *Delay-Adaptive Linear Control* and *Adaptive Control of Parabolic PDEs* (both Princeton).

2022. 512 pages. 137 b/w illus. 19 tables.
 Hardback 9780691233482 \$165.00 | £138.00
 Paperback 9780691233499 \$70.00 | £58.00 ebook 9780691233505

“A valuable resource for control theorists and practitioners, this is the first book to deal with the emerging field of event-triggered control for PDEs. Easy to read and technically sound, it has an excellent balance between theory and applications, making the practical significance of the methods clear.”
 —Joachim Deutscher, Ulm University, Germany

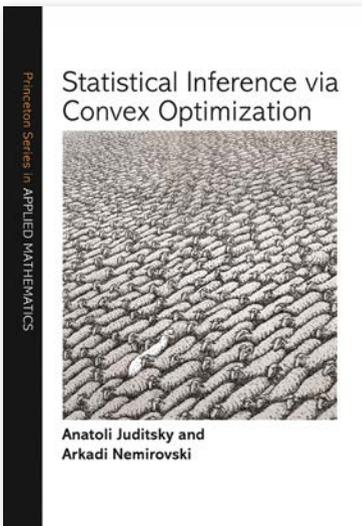


Delay-Adaptive Linear Control

Delay-Adaptive Linear Control develops adaptive predictor feedback algorithms equipped with online estimators of unknown delays and other parameters. This comprehensive book solves adaptive delay compensation problems for systems with single and multiple inputs/outputs, unknown and distinct delays in different input channels, unknown delay kernels, unknown plant parameters, unmeasurable finite-dimensional plant states, and unmeasurable infinite-dimensional actuator states. *Delay-Adaptive Linear Control* offers powerful new tools for the control engineer and the mathematician.

Yang Zhu is a postdoctoral researcher in control theory and engineering at Tel Aviv University. **Miroslav Krstic** is distinguished professor of mechanical and aerospace engineering at the University of California, San Diego, where he also serves as senior associate vice chancellor for research.

2020.352 pages. 48 b/w illus. 16 tables.
 Hardback 9780691202549 \$95.00 | £80.00 ebook 9780691203317

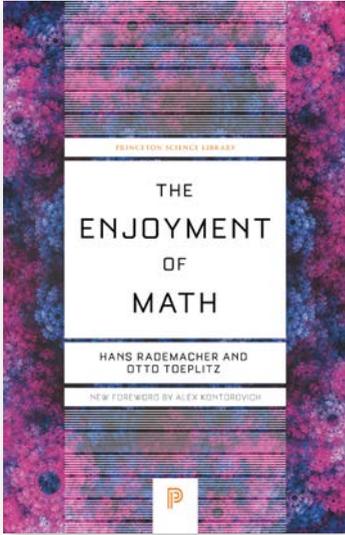


Statistical Inference via Convex Optimization

Through an accessible analysis of fundamental problems of hypothesis testing and signal recovery, Anatoli Juditsky and Arkadi Nemirovski show how convex optimization theory can be used to devise and analyze near-optimal statistical inferences. *Statistical Inference via Convex Optimization* is an essential resource for optimization specialists who are new to statistics and its applications, and for data scientists who want to improve their optimization methods.

Anatoli Juditsky is professor of applied mathematics and chair of statistics and optimization at the Multidisciplinary Institute in Artificial Intelligence at the Université Grenoble Alpes in France. **Arkadi Nemirovski** is the John Hunter Chair and professor of industrial and systems engineering at the Georgia Institute of Technology. His books include *Robust Optimization* (Princeton).

2020. 656 pages. 40 b/w illus.
 Hardback 9780691197296 \$95.00 | £80.00 ebook 9780691200316



“A thoroughly enjoyable sampler of fascinating mathematical problems and their solutions.”

—*Science*

The classic book that shares the enjoyment of mathematics with readers of all skill levels

The Enjoyment of Math

What is so special about the number 30? Do the prime numbers go on forever? Are there more whole numbers than even numbers? *The Enjoyment of Math* explores these and other captivating problems and puzzles, introducing readers to some of the most fundamental ideas in mathematics. Written by two eminent mathematicians and requiring only a background in plane geometry and elementary algebra, this delightful book covers topics such as the theory of sets, the four-color problem, regular polyhedrons, Euler’s proof of the infinitude of prime numbers, and curves of constant breadth. Along the way, it discusses the history behind the problems, carefully explaining how each has arisen and, in some cases, how to resolve it. With an incisive foreword by Alex Kontorovich, this Princeton Science Library edition shares the enjoyment of math with a new generation of readers.

Hans Rademacher (1892–1969) was professor emeritus of mathematics at the University of Pennsylvania.

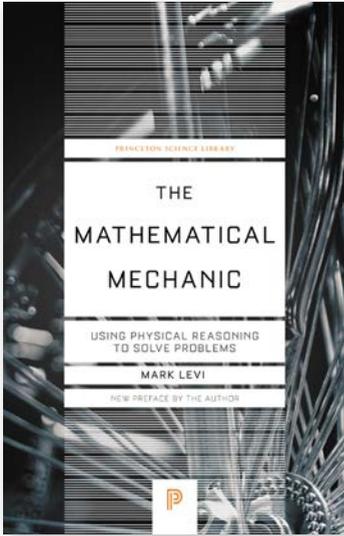
Otto Toeplitz (1881–1940) was a leading mathematician specializing in linear algebra and functional analysis.

Alex Kontorovich is professor of mathematics at Rutgers University.

January 2023. 224 pages. 123 b/w illus.

Paperback 9780691241548 \$19.95 | £16.99

ebook 9780691241531



How physics can give quick solutions to an array of math problems

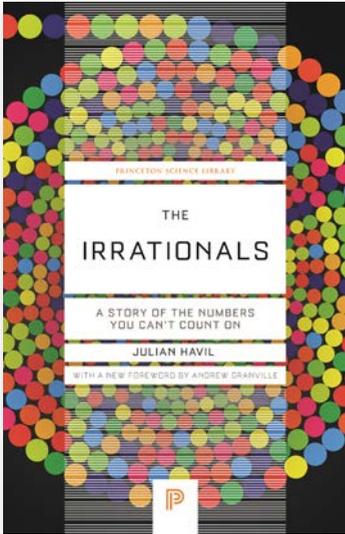
The Mathematical Mechanic

Everybody knows that mathematics is indispensable to physics—imagine where we’d be if Newton and Einstein hadn’t had the math to back up their ideas. But how many people realize that physics can be used to produce many astonishing and strikingly elegant solutions in mathematics? Mark Levi shows how in this delightful book, treating readers to a host of entertaining problems and mind-bending puzzlers. Turning math and physics upside down, Levi reveals how physics can simplify proofs and lead to quicker solutions and new theorems, and how physical solutions can illustrate why results are true in ways lengthy mathematical calculations never can. *The Mathematical Mechanic* will appeal to anyone interested in the little-known connections between mathematics and physics and how both endeavors relate to the world around us.

Mark Levi is professor of mathematics at Pennsylvania State University. He is also the author of *Why Cats Land on Their Feet: And 76 Other Physical Paradoxes and Puzzles* (Princeton).

January 2023. 216 pages. 122 b/w illus. 1 table.
Paperback 9780691242057 \$18.95 | £15.99 ebook 9780691244174

“A pleasure to read.... Newton himself would have been charmed by this book.”
—Steven G. Krantz, *UMAP Journal*



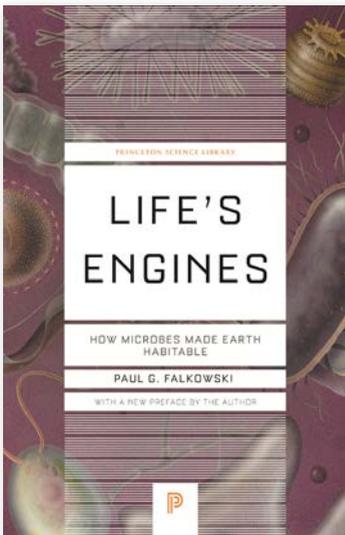
An entertaining and enlightening history of irrational numbers, from ancient Greece to the twenty-first century

The Irrationals

The ancient Greeks discovered them, but it wasn't until the nineteenth century that irrational numbers were properly understood and rigorously defined, and even today not all their mysteries have been revealed. In *The Irrationals*, Julian Havil tells the story of irrational numbers and the mathematicians who have tackled their challenges, from antiquity to the twenty-first century. Fascinating and illuminating, this is a book for everyone who loves math and the history behind it.

Julian Havil is the author of many popular mathematics books, including *Gamma*, *Nonplussed!*, and *Curves for the Mathematically Curious* (all Princeton). **Andrew Granville** is the Canada Research Chair in Number Theory at the University of Montreal and professor of mathematics at University College London.

June 2023. 312 pages. 100 b/w illus.
 Paperback 9780691247663 \$19.95 | £16.99 ebook 9780691247670



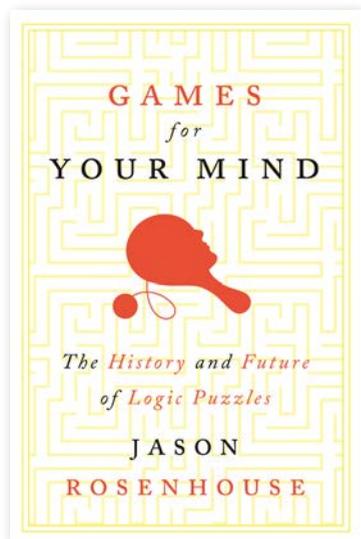
The marvelous microbes that made life on Earth possible and support our very existence

Life's Engines

For almost four billion years, microbes had the primordial oceans all to themselves. The stewards of Earth, these organisms transformed the chemistry of our planet to make it habitable for plants, animals, and us. Paul Falkowski takes readers deep into the microscopic world to explore how these marvelous creatures made life on Earth possible—and how human life today would cease to exist without them. A vibrantly entertaining book about the microbes that support our very existence, *Life's Engines* will inspire wonder about these elegantly complex nano-machines that have driven life since its origin.

Paul G. Falkowski holds the Bennett L. Smith Chair in Business and Natural Resources at Rutgers University.

June 2023. 224 pages. 38 b/w illus.
 Paperback 9780691247687 \$19.95 | £16.99 ebook 9780691247694



“[A] fascinating book.... Ingenious.”
—Amy Barrett, *BBC Science Focus*

“Logic is one of the most important subjects in mathematics and Jason Rosenhouse’s welcoming style makes it easy to understand. A fantastic achievement!”

—James Grime, presenter of
Numberphile

A lively and engaging look at logic puzzles and their role in mathematics, philosophy, and recreation

Games for Your Mind

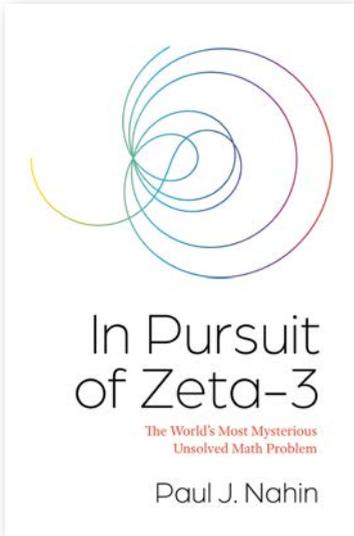
Logic puzzles were first introduced to the public by Lewis Carroll in the late nineteenth century and have been popular ever since. Games like Sudoku and Mastermind are fun and engrossing recreational activities, but they also share deep foundations in mathematical logic and are worthy of serious intellectual inquiry. *Games for Your Mind* explores the history and future of logic puzzles while enabling you to test your skill against a variety of puzzles yourself.

In this informative and entertaining book, Jason Rosenhouse begins by introducing readers to logic and logic puzzles and goes on to reveal the rich history of these puzzles. He shows how Carroll’s puzzles presented Aristotelian logic as a game for children, yet also informed his scholarly work on logic. He reveals how another pioneer of logic puzzles, Raymond Smullyan, drew on classic puzzles about liars and truth-tellers to illustrate Kurt Gödel’s theorems and illuminate profound questions in mathematical logic. Rosenhouse then presents a new vision for the future of logic puzzles based on nonclassical logic, which is used today in computer science and automated reasoning to manipulate large and sometimes contradictory sets of data.

Featuring a wealth of sample puzzles ranging from simple to extremely challenging, this lively and engaging book brings together many of the most ingenious puzzles ever devised, including the “Hardest Logic Puzzle Ever,” metapuzzles, paradoxes, and the logic puzzles in detective stories.

Jason Rosenhouse is professor of mathematics at James Madison University. He is the author of *The Monty Hall Problem: The Remarkable Story of Math’s Most Contentious Brain Teaser* and *Among the Creationists: Dispatches from the Anti-Evolutionist Front Line*. He is the coauthor (with Laura Taalman) of *Taking Sudoku Seriously: The Math behind the World’s Most Popular Pencil Puzzle* and the coeditor (with Jennifer Beineke) of *The Mathematics of Various Entertaining Subjects* (Vols. 1–3) (Princeton).

2022. 352 pages. 35 b/w illus. 32 tables.
Paperback 9780691242026 \$24.95 | £20.00 ebook 9780691200347



“Nahin’s style is entertaining, directly addressing his readers.... Highly recommended.”

—Adhemar Bultheel, *MAA Reviews*

An engrossing look at the history and importance of a centuries-old but still unanswered math problem

In Pursuit of Zeta-3

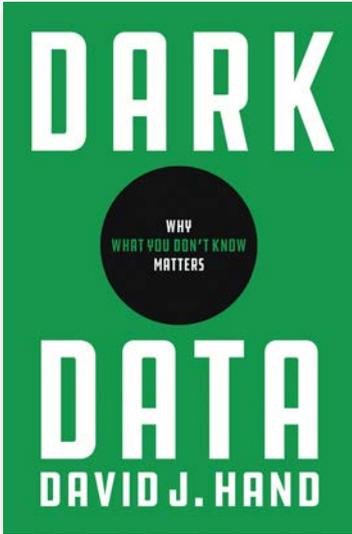
For centuries, mathematicians the world over have tried, and failed, to solve the zeta-3 problem. Math genius Leonhard Euler attempted it in the 1700s and came up short. The straightforward puzzle considers if there exists a simple symbolic formula for the following: $1 + (\frac{1}{2})^3 + (\frac{1}{3})^3 + (\frac{1}{4})^3 + \dots$. But why is this issue—the sum of the reciprocals of the positive integers cubed—so important? With *In Pursuit of Zeta-3*, popular math writer Paul Nahin investigates the history and significance of this mathematical conundrum.

Drawing on detailed examples, historical anecdotes, and even occasionally poetry, Nahin sheds light on the richness of the nature of zeta-3. He shows its intimate connections to the Riemann hypothesis, another mathematical mystery that has stumped mathematicians for nearly two centuries. He looks at its links with Euler’s achievements and explores the modern research area of Euler sums, where zeta-3 occurs frequently. An exact solution to the zeta-3 question wouldn’t simply satisfy pure mathematical interest: it would have critical ramifications for applications in physics and engineering, such as quantum electrodynamics. Challenge problems with detailed solutions and *MATLAB* code are included at the end of each of the book’s sections.

Detailing the trials and tribulations of mathematicians who have approached one of the field’s great unsolved riddles, *In Pursuit of Zeta-3* will tantalize curious math enthusiasts everywhere.

Paul J. Nahin is the author of many popular math books, including *How to Fall Slower Than Gravity*, *Dr. Euler’s Fabulous Formula*, and *An Imaginary Tale* (all Princeton). He is professor emeritus of electrical engineering at the University of New Hampshire and received the 2017 Chandler Davis Prize for Excellence in Expository Writing in Mathematics. He lives in Exeter, New Hampshire.

May 2023. 344 pages. 23 b/w illus.
Paperback 9780691247649 \$21.95 | £17.99 ebook 9780691227597



“[A] penetrating study of missing (‘dark’) data and its impacts on decisions—skewing stats, enabling fraud, embedding inequity and triggering preventable catastrophes. Advocating ‘data science judo,’ Hand offers expert training, from recognizing when facts are being cherry-picked to designing randomized trials. A book illuminating shadowed corners in science, medicine and policy.”

—Barbara Kiser, *Nature*

A practical guide to making good decisions in a world of missing data

Dark Data

In the era of big data, it is easy to imagine that we have all the information we need to make good decisions. But in fact the data we have are never complete, and may be only the tip of the iceberg. Just as much of the universe is composed of dark matter, invisible to us but nonetheless present, the universe of information is full of dark data that we overlook at our peril. In *Dark Data*, data expert David Hand takes us on a fascinating and enlightening journey into the world of the data we *don't* see.

Dark Data explores the many ways in which we can be blind to missing data and how that can lead us to conclusions and actions that are mistaken, dangerous, or even disastrous. Examining a wealth of real-life examples, from the Challenger shuttle explosion to complex financial frauds, Hand gives us a practical taxonomy of the types of dark data that exist and the situations in which they can arise, so that we can learn to recognize and control for them. In doing so, he teaches us not only to be alert to the problems presented by the things we don't know, but also shows how dark data can be used to our advantage, leading to greater understanding and better decisions.

Today, we all make decisions using data. *Dark Data* shows us all how to reduce the risk of making bad ones.

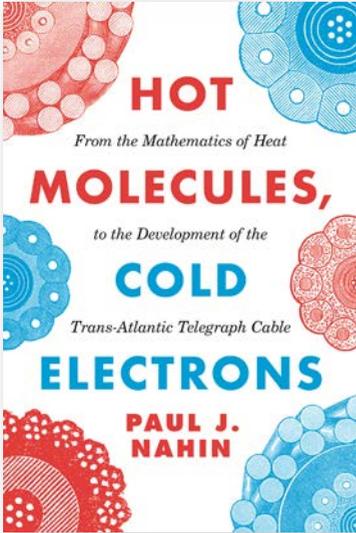
David J. Hand is emeritus professor of mathematics and senior research investigator at Imperial College London, a former president of the Royal Statistical Society, and a fellow of the British Academy. His many previous books include *The Improbability Principle*, *Measurement: A Very Short Introduction*, *Statistics: A Very Short Introduction*, and *Principles of Data Mining*.

2022. 344 pages. 6 b/w illus. 6 tables.

Paperback 9780691234465 \$19.95 | £16.99

ebook 9780691198859

Audiobook 9780691199177



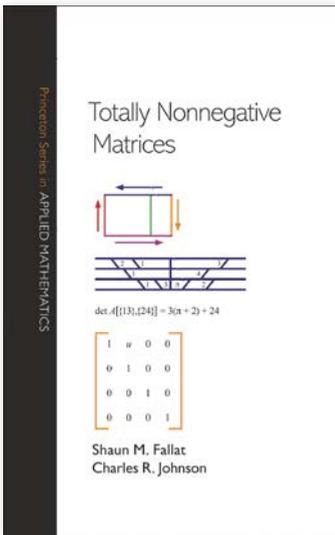
An entertaining mathematical exploration of the heat equation and its role in the triumphant development of the trans-Atlantic telegraph cable

Hot Molecules, Cold Electrons

Heat, like gravity, shapes nearly every aspect of our world and universe, from how milk dissolves in coffee to how molten planets cool. The heat equation, a cornerstone of modern physics, demystifies such processes, painting a mathematical picture of the way heat diffuses through matter. Presenting the mathematics and history behind the heat equation, *Hot Molecules, Cold Electrons* tells the remarkable story of how this foundational idea brought about one of the greatest technological advancements of the modern era, the pioneering trans-Atlantic telegraph cable.

Paul J. Nahin is professor emeritus of electrical engineering at the University of New Hampshire.

2022. 232 pages. 37 b/w illus.
 Paperback 9780691207841 \$17.95 | £14.99 ebook 9780691199948

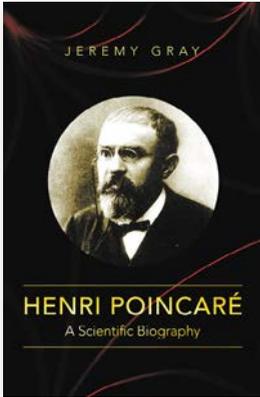


Totally Nonnegative Matrices

Totally nonnegative matrices arise in a remarkable variety of mathematical applications. This book is a comprehensive and self-contained study of the essential theory of totally nonnegative matrices, defined by the nonnegativity of all subdeterminants. It explores methodological background, historical highlights of key ideas, and specialized topics. The book uses classical and ad hoc tools, but a unifying theme is the elementary bidiagonal factorization, which has emerged as the single most important tool for this particular class of matrices.

Shaun M. Fallat is professor of mathematics and statistics at the University of Regina. **Charles R. Johnson** is the Class of 1961 Professor of Mathematics at the College of William & Mary.

December 2022. 264 pages. 21 b/w illus. 3 tables.
 Paperback 9780691242415 \$55.00 | £45.00 ebook 9781400839018



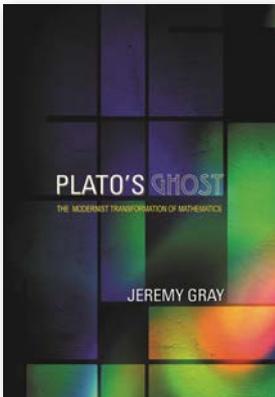
Henri Poincaré

Henri Poincaré (1854–1912) was not just one of the most inventive, versatile, and productive mathematicians of all time—he was also a leading physicist who almost won a Nobel Prize for physics and a prominent philosopher of science whose fresh and surprising essays are still in print a century later. The first in-depth and comprehensive look at his many accomplishments, *Henri Poincaré* explores all the fields that Poincaré touched, the debates sparked by his original investigations, and how his discoveries still contribute to society today.

Jeremy Gray is professor of the history of mathematics at the Open University, and an honorary professor at the University of Warwick.

December 2022. 608 pages. 39 b/w illus.

Paperback 9780691242033 \$35.00 | £30.00 ebook 9781400844791



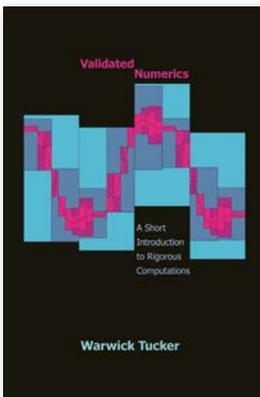
Plato's Ghost

Plato's Ghost is the first book to examine the development of mathematics from 1880 to 1920 as a modernist transformation similar to those in art, literature, and music. Jeremy Gray traces the growth of mathematical modernism from its roots in problem solving and theory to its interactions with physics, philosophy, theology, psychology, and ideas about real and artificial languages. *Plato's Ghost* is essential reading for mathematicians and historians, and will appeal to anyone interested in the development of modern mathematics.

Jeremy Gray is professor of the history of mathematics at the Open University, and an honorary professor at the University of Warwick.

December 2022. 528 pages. 36 b/w illus.

Paperback 9780691242040 \$39.95 | £30.00 ebook 9781400829040



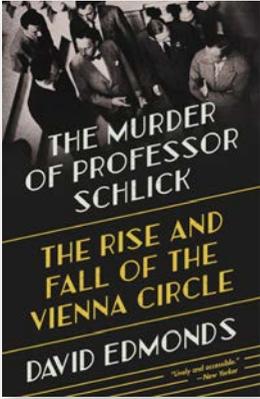
Validated Numerics

This textbook provides a comprehensive introduction to the theory and practice of validated numerics, an emerging new field that combines the strengths of scientific computing and pure mathematics. This book is an essential resource for those entering this fast-developing field, and it is also the ideal textbook for graduate students and advanced undergraduates needing an accessible introduction to the subject.

Warwick Tucker is professor of mathematics and principal investigator for the Computer-Aided Proofs in Analysis (CAPA) Group at Uppsala University in Sweden.

June 2023. 152 pages. 41 line illus. 12 tables.

Paperback 9780691247656 \$45.00 | £38.00 ebook 9781400838974



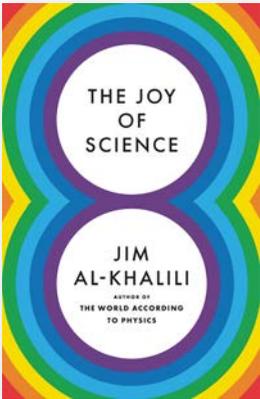
The story of an extraordinary group of philosophers during a dark chapter in Europe's history

The Murder of Professor Schlick

Weaving a narrative set against the backdrop of rising extremism in Hitler's Europe, this book traces the rise and fall of the Vienna Circle and of a philosophical movement that sought to do away with metaphysics and pseudoscience in a city darkened by unreason.

David Edmonds is a distinguished research fellow at the Oxford Uehiro Centre for Practical Ethics.

2022. 336 pages. 23 b/w illus.
Paperback 9780691211961 \$17.95 | £14.99 ebook 9780691185842



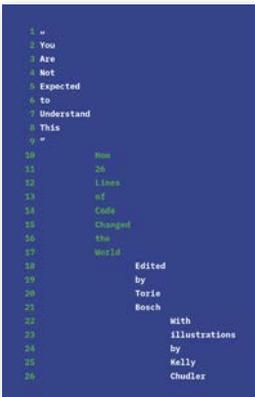
Jim Al-Khalili reveals how 8 lessons from the core of science can help you get the most out of life

The Joy of Science

The Joy of Science presents 8 short lessons on how to unlock the clarity and joy of thinking and living a little more scientifically. It will empower you to think more objectively, see through the fog of your own preexisting beliefs, and lead a more fulfilling life.

Jim Al-Khalili is Distinguished Professor of Theoretical Physics at the University of Surrey.

2022. 224 pages.
Hardback 9780691211572 \$16.95 | £13.99 ebook 9780691235660

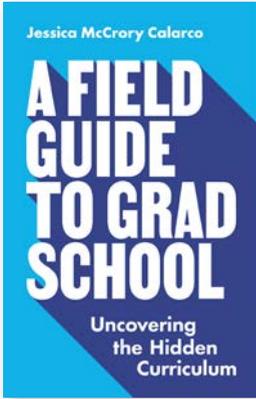


“You Are Not Expected to Understand This”

Few of us give much thought to computer code or how it comes to be. The very word “code” makes it sound immutable or even inevitable. “*You Are Not Expected to Understand This*” demonstrates that, far from being preordained, computer code is the result of very human decisions, ones we all live with when we use social media, take photos, drive our cars, and engage in a host of other activities.

Torie Bosch is editor of Future Tense, a partnership of Slate, New America, and Arizona State University that explores the intersection of technology, policy, and society. **Kelly Chudler** is a multidisciplinary artist and musician.

November 2022. 216 pages. 19 b/w illus.
Paperback 9780691208480 \$19.95 | £16.99
ebook 9780691230818 Audiobook 9780691249933

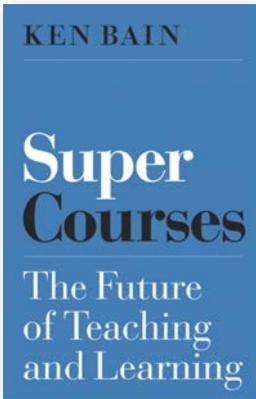


A Field Guide to Grad School

In this comprehensive survival guide for grad school, Jessica McCrory Calarco walks you through the secret knowledge and skills that are essential for navigating every critical stage of the postgraduate experience, from deciding whether to go to grad school in the first place to finishing your degree and landing a job. An invaluable resource for every prospective and current grad student in any discipline, *A Field Guide to Grad School* will save you grief—and help you thrive—in school and beyond.

Jessica McCrory Calarco is associate professor of sociology at Indiana University.

2020. 480 pages. 18 b/w illus. 2 tables.
 Paperback 9780691201092 \$17.95 | £14.99 ebook 9780691201108



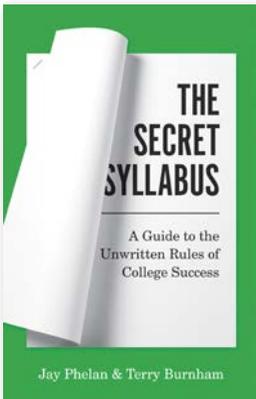
The story of a new breed of amazingly innovative courses that inspire students and improve learning

Super Courses

Super Courses tells the fascinating story of college, graduate school, and high school teachers who are using evidence-based approaches to spark deeper levels of learning, critical thinking, and creativity.

Ken Bain taught as a history professor for many years and is the president of the Best Teachers Institute.

2022. 304 pages.
 Paperback 9780691182568 \$22.95 | £18.99 ebook 9780691216591



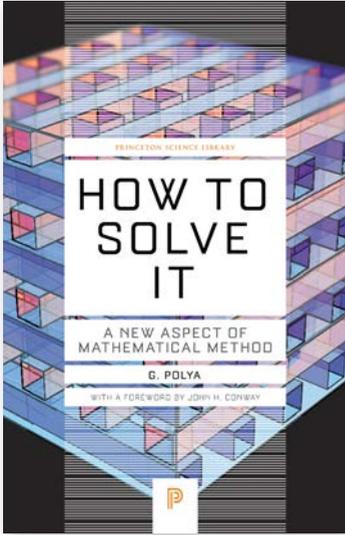
The unwritten rules of success that every student must follow to thrive in college

The Secret Syllabus

The Secret Syllabus equips students with the tools they need to succeed, revealing the unwritten rules and cultural norms and expectations not included in the official curriculum.

Jay Phelan received his PhD in biology from Harvard University and is on the life sciences faculty at UCLA. **Terry Burnham** received his PhD in business economics from Harvard and is a finance professor at Chapman University.

2022. 288 pages.
 Hardback 9780691224404 \$55.00 | £45.00
 Paperback 9780691224428 \$18.95 | £15.99 ebook 9780691224411

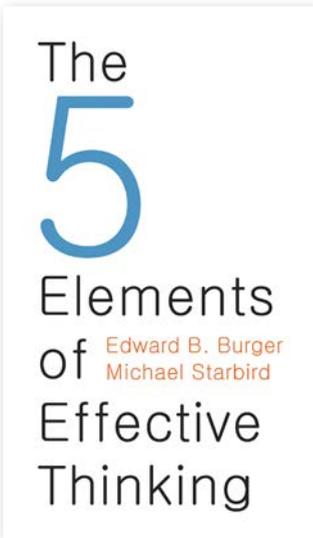


How to Solve It

A perennial bestseller by eminent mathematician G. Polya, *How to Solve It* will show anyone in any field how to think straight. In lucid and appealing prose, Polya reveals how the mathematical method of demonstrating a proof or finding an unknown can be of help in attacking any problem that can be “reasoned” out—from building a bridge to winning a game of anagrams. Generations of readers have relished Polya’s deft—indeed, brilliant—instructions on stripping away irrelevancies and going straight to the heart of the problem.

George Polya (1887–1985) was one of the most influential mathematicians of the twentieth century. His basic research contributions span complex analysis, mathematical physics, probability theory, geometry, and combinatorics. **John H. Conway** (1937–2020) was professor emeritus of mathematics at Princeton University. He was awarded the London Mathematical Society’s Polya Prize in 1987.

2014. 288 pages. 31 line illus.
Paperback 9780691164076 \$19.95 | £16.99 ebook 9781400828678



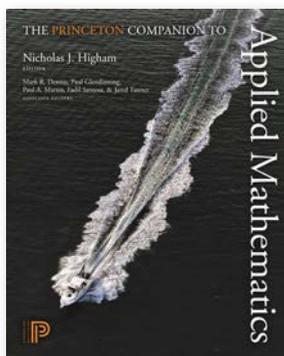
Simple but powerful strategies for increasing your success by improving your thinking

The 5 Elements of Effective Thinking

The 5 Elements of Effective Thinking presents practical, lively, and inspiring ways for you to become more successful through better thinking. The idea is simple: You can learn how to think far better by adopting specific strategies. Brilliant people aren’t a special breed—they just use their minds differently.

Edward B. Burger is president and CEO of the St. David’s Foundation, president emeritus of Southwestern University, and an educational and business consultant. **Michael Starbird** is University Distinguished Teaching Professor at The University of Texas at Austin and an educational and business consultant.

2012. 168 pages. 1 line illus.
Hardback 9780691156668 \$19.95 | £16.99 ebook 9781400844562



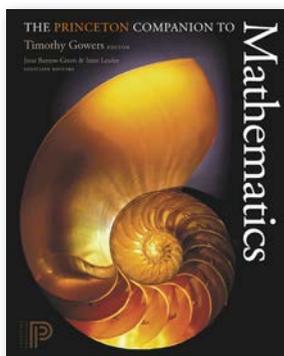
The must-have compendium on applied mathematics

The Princeton Companion to Applied Mathematics

This book introduces readers to applied mathematics and its uses; explains key concepts; describes important equations, laws, and functions; looks at exciting areas of research; covers modeling and simulation; explores areas of application; and more.

Nicholas J. Higham, Mark R. Dennis, Paul Glendinning, Paul A. Martin, Fadil Santosa & Jared Tanner

2015. 1032 pages. 23 color illus. 20 halftones. 160 line illus.
Hardback 9780691150390 \$99.95 | £84.00 ebook 9781400874477



The Princeton Companion to Mathematics

This book presents nearly two hundred entries, written especially for this book by some of the world's leading mathematicians, that introduce basic mathematical tools and vocabulary; trace the development of modern mathematics; explain essential terms and concepts; examine core ideas in major areas of mathematics; describe the achievements of scores of famous mathematicians; explore the impact of mathematics on other disciplines such as biology, finance, and music—and much, much more.

Timothy Gowers, June Barrow-Green & Imre Leader.

2008. 1056 pages.
Hardback 9780691118802 \$99.50 | £84.00 ebook 9781400830398

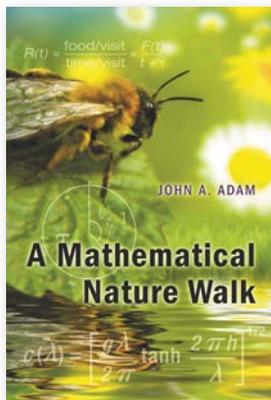


Guesstimation

Guesstimation is a book that unlocks the power of approximation—it's popular mathematics rounded to the nearest power of ten! The ability to estimate is an important skill in daily life. More and more leading businesses today use estimation questions in interviews to test applicants' abilities to think on their feet. *Guesstimation* enables anyone with basic math and science skills to estimate virtually anything—quickly—using plausible assumptions and elementary arithmetic.

Lawrence Weinstein is professor of physics at Old Dominion University. **John A. Adam** is professor of mathematics at Old Dominion University.

2008. 320 pages. 72 line illus.
Paperback 9780691129495 \$19.95 | £16.99 ebook 9781400824441

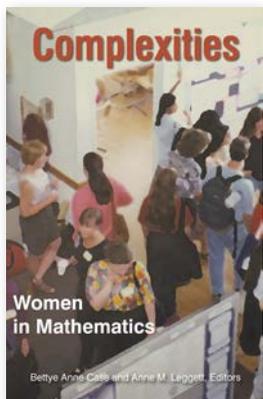


A Mathematical Nature Walk

How heavy is that cloud? Why can you see farther in rain than in fog? Why are the droplets on that spider web spaced apart so evenly? If you have ever asked questions like these while outdoors, and wondered how you might figure out the answers, this is a book for you. An entertaining and informative collection of fascinating puzzles from the natural world around us, *A Mathematical Nature Walk* will delight anyone who loves nature or math or both.

John A. Adam is professor of mathematics at Old Dominion University.

2011. 280 pages. 17 color illus. 22 halftones. 97 line illus.
Paperback 9780691152653 \$21.95 | £17.99 ebook 9781400832903



Complexities

This captivating book gives voice to women mathematicians from the late eighteenth century through to the present day. It documents the complex nature of the conditions women around the world have faced—and continue to face—while pursuing their careers in mathematics.

Bettye Anne Case is Olga Larson Professor of Mathematics at Florida State University. **Anne M. Leggett** is Associate Professor of Mathematics at Loyola University, Chicago.

2016. 456 pages.
Paperback 9780691171098 \$35.00 | £30.00 ebook 9781400880164



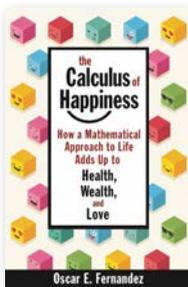
Mathematics and Art

Mathematicians and artists have long been on a quest to understand the physical world they see before them and the abstract objects they know by thought alone. Taking readers on a tour of the practice of mathematics and the philosophical ideas that drive the discipline, Lynn Gamwell points out the important ways mathematical concepts have been expressed by artists. Sumptuous illustrations of artworks and cogent math diagrams are featured in Gamwell's comprehensive exploration.

Lynn Gamwell is lecturer in the history of art, science, and mathematics at the School of Visual Arts in New York. She is the author of *Exploring the Invisible: Art, Science, and the Spiritual* (Princeton).

2015. 576 pages. 444 color + 102 b/w illus.
Hardback 9780691165288 \$55.00 | £45.00

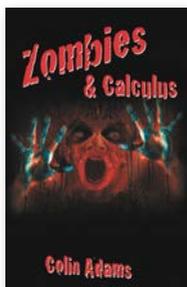
NEED CALCULUS? WE'VE GOT YOU COVERED



The Calculus of Happiness

Oscar E. Fernandez

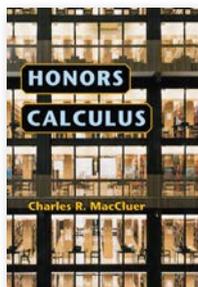
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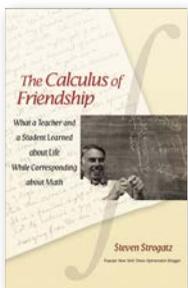
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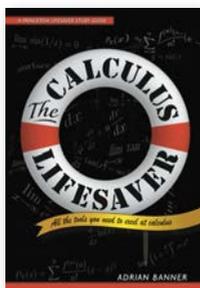
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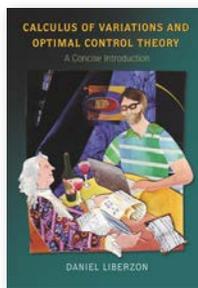
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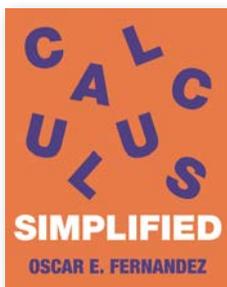
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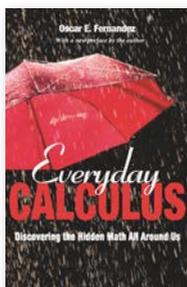
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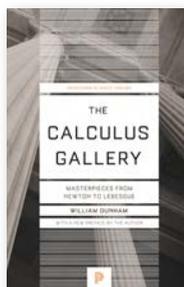
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