

# Math Research Papers

Wow! This is a powerful book that addresses a long-standing elephant in the mathematics room. Many people learning math ask "Why is math so hard for me while everyone else understands it?" and "Am I good enough to succeed in math?" In answering these questions the book shares personal stories from many now-accomplished mathematicians affirming that "You are not alone; math is hard for everyone" and "Yes; you are good enough." Along the way the book addresses other issues such as biases and prejudices that mathematicians encounter, and it provides inspiration and emotional support for mathematicians ranging from the experienced professor to the struggling mathematics student. --Michael Dorff, MAA President This book is a remarkable collection of personal reflections on what it means to be, and to become, a mathematician. Each story reveals a unique and refreshing understanding of the barriers erected by our cultural focus on "math is hard." Indeed, mathematics is hard, and so are many other things--as Stephen Kennedy points out in his cogent introduction. This collection of essays offers inspiration to students of mathematics and to mathematicians at every career stage. --Jill Pipher, AMS President This book is published in cooperation with the Mathematical Association of America. This is a one-of-a-kind reference for anyone with a serious interest in mathematics. Edited by Timothy Gowers, a recipient of the Fields Medal, it presents nearly two

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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. Unparalleled in its depth of coverage, *The Princeton Companion to Mathematics* surveys the most active and exciting branches of pure mathematics. Accessible in style, this is an indispensable resource for undergraduate and graduate students in mathematics as well as for researchers and scholars seeking to understand areas outside their specialties. Features nearly 200 entries, organized thematically and written by an international team of distinguished contributors Presents major ideas and branches of pure mathematics in a clear, accessible style Defines and explains important mathematical concepts, methods, theorems, and open problems Introduces the language of mathematics and the goals of mathematical research Covers number theory, algebra, analysis, geometry, logic, probability, and more Traces the history and development of modern mathematics Profiles more than ninety-five mathematicians who influenced those working today Explores the influence of mathematics on other disciplines Includes bibliographies, cross-references, and a comprehensive index Contributors include: Graham Allan, Noga Alon, George Andrews, Tom Archibald, Sir Michael Atiyah, David

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Aubin, Joan Bagaria, Keith Ball, June Barrow-Green, Alan Beardon, David D. Ben-Zvi, Vitaly Bergelson, Nicholas Bingham, Béla Bollobás, Henk Bos, Bodil Branner, Martin R. Bridson, John P. Burgess, Kevin Buzzard, Peter J. Cameron, Jean-Luc Chabert, Eugenia Cheng, Clifford C. Cocks, Alain Connes, Leo Corry, Wolfgang Coy, Tony Crilly, Serafina Cuomo, Mihalis Dafermos, Partha Dasgupta, Ingrid Daubechies, Joseph W. Dauben, John W. Dawson Jr., Francois de Gandt, Persi Diaconis, Jordan S. Ellenberg, Lawrence C. Evans, Florence Fasanelli, Anita Burdman Feferman, Solomon Feferman, Charles Fefferman, Della Fenster, José Ferreirós, David Fisher, Terry Gannon, A. Gardiner, Charles C. Gillispie, Oded Goldreich, Catherine Goldstein, Fernando Q. Gouvêa, Timothy Gowers, Andrew Granville, Ivor Grattan-Guinness, Jeremy Gray, Ben Green, Ian Grojnowski, Niccolò Guicciardini, Michael Harris, Ulf Hashagen, Nigel Higson, Andrew Hodges, F. E. A. Johnson, Mark Joshi, Kiran S. Kedlaya, Frank Kelly, Sergiu Klainerman, Jon Kleinberg, Israel Kleiner, Jacek Klinowski, Eberhard Knobloch, János Kollár, T. W. Körner, Michael Krivelevich, Peter D. Lax, Imre Leader, Jean-François Le Gall, W. B. R. Lickorish, Martin W. Liebeck, Jesper Lützen, Des MacHale, Alan L. Mackay, Shahn Majid, Lech Maligranda, David Marker, Jean Mawhin, Barry Mazur, Dusa McDuff, Colin McLarty, Bojan Mohar, Peter M. Neumann, Catherine Nolan, James Norris, Brian Osserman, Richard S. Palais, Marco Panza, Karen Hunger Parshall, Gabriel P. Paternain, Jeanne Peiffer, Carl Pomerance, Helmut Pulte, Bruce Reed, Michael C. Reed, Adrian Rice, Eleanor Robson, Igor Rodnianski, John Roe,

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Mark Ronan, Edward Sandifer, Tilman Sauer, Norbert Schappacher, Andrzej Schinzel, Erhard Scholz, Reinhard Siegmund-Schultze, Gordon Slade, David J. Spiegelhalter, Jacqueline Stedall, Arild Stubhaug, Madhu Sudan, Terence Tao, Jamie Tappenden, C. H. Taubes, Rüdiger Thiele, Burt Totaro, Lloyd N. Trefethen, Dirk van Dalen, Richard Weber, Dominic Welsh, Avi Wigderson, Herbert Wilf, David Wilkins, B. Yandell, Eric Zaslow, Doron Zeilberger

The Kepler conjecture, one of geometry's oldest unsolved problems, was formulated in 1611 by Johannes Kepler and mentioned by Hilbert in his famous 1900 problem list. The Kepler conjecture states that the densest packing of three-dimensional Euclidean space by equal spheres is attained by the "cannonball" packing. In a landmark result, this was proved by Thomas C. Hales and Samuel P. Ferguson, using an analytic argument completed with extensive use of computers. This book centers around six papers, presenting the detailed proof of the Kepler conjecture given by Hales and Ferguson, published in 2006 in a special issue of *Discrete & Computational Geometry*. Further supporting material is also presented: a follow-up paper of Hales et al (2010) revising the proof, and describing progress towards a formal proof of the Kepler conjecture. For historical reasons, this book also includes two early papers of Hales that indicate his original approach to the conjecture. The editor's two introductory chapters situate the conjecture in a broader historical and mathematical context. These chapters provide a valuable perspective and are a key feature of this work.

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This is the first book to present a detailed discussion of both classical and recent results on the popular Cahn–Hilliard equation and some of its variants. The focus is on mathematical analysis of Cahn–Hilliard models, with an emphasis on thermodynamically relevant logarithmic nonlinear terms, for which several questions are still open. Initially proposed in view of applications to materials science, the Cahn–Hilliard equation is now applied in many other areas, including image processing, biology, ecology, astronomy, and chemistry. In particular, the author addresses applications to image inpainting and tumor growth. Many chapters include open problems and directions for future research. The Cahn-Hilliard Equation: Recent Advances and Applications is intended for graduate students and researchers in applied mathematics, especially those interested in phase separation models and their generalizations and applications to other fields. Materials scientists also will find this text of interest.

Annotation. Researchers and graduate students in the theory of stochastic processes will find in this 35th volume some thirty articles on martingale theory, martingales and finance, analytical inequalities and semigroups, stochastic differential equations, functionals of Brownian motion and of Lévy processes. Ledoux's article contains a self-contained introduction to the use of semigroups in spectral gaps and logarithmic Sobolev inequalities; the contribution by Emery and Schachermayer includes an exposition for probabilists of Vershik's theory of backward discrete filtrations.

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The tenth edition of the four-yearly review of mathematics education research in Australasia, compiled by the Mathematics Education Research Group of Australasia (MERGA), critically reviews research in mathematics education in the four years from 2016 to 2019. Its goals are to provide a reference guide for researchers, and to promote further quality research in Australasia.

Rediscovering Mathematics is aimed at a general audience and addresses the question of how best to teach and study mathematics. The book attempts to bring the exciting and dynamic world of mathematics to a non-technical audience. With so much focus today on how best to educate the new generation and make mathematics less rote and more interactive, this book is an eye-opening experience for many people who suffered with dull math teachers and curricula. Rediscovering Mathematics is an eclectic collection of mathematical topics and puzzles aimed at talented youngsters and inquisitive adults who want to expand their view of mathematics. By focusing on problem solving, and discouraging rote memorization, the book shows how to learn and teach mathematics through investigation, experimentation, and discovery.

Rediscovering Mathematics is also an excellent text for training math teachers at all levels. Topics range in difficulty and cover a wide range of historical periods, with some examples demonstrating how to uncover mathematics in everyday life, including: number theory and its application to secure communication over the Internet, the algebraic and combinatorial work of a medieval mathematician Rabbi, and applications

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of probability to sports, casinos, and gambling. Rediscovering Mathematics provides a fresh view of mathematics for those who already like the subject, and offers a second chance for those who think they don't.

""Presents the latest in graph domination by leading researchers from around the world-furnishing known results, open research problems, and proof techniques.

Maintains standardized terminology and notation throughout for greater accessibility. Covers recent developments in domination in graphs and digraphs, dominating functions, combinatorial problems on chessboards, and more.

"One of the themes of the book is how to have a fulfilling professional life. In order to achieve this goal, Krantz discusses keeping a vigorous scholarly program going and finding new challenges, as well as dealing with the everyday tasks of research, teaching, and administration." "In short, this is a survival manual for the professional mathematician - both in academics and in industry and government agencies. It is a sequel to the author's A Mathematician's Survival Guide."--BOOK JACKET.

Analysis, et cetera: Research Papers Published in Honor of Jürgen Moser's 60th Birthday provides a collection of papers dedicated to Jürgen Moser on the occasion of his 60th birthday. This book covers a variety of topics, including Helmholtz equation, algebraic complex integrability, theory of Lie groups, and

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trigonometric polynomials. Organized into 31 chapters, this book begins with an overview of some basic consequences of the definition of algebraic complete integrability. This text then derives a representation theorem for solutions of the Helmholtz equation. Other chapters consider the integrable generalizations of the Volterra system and explain the dynamical system in the finite-dimensional case. This book discusses as well the global periodic solutions for the planar triple pendulum. The final chapter deals with the problem of deriving the macroscopic conservation laws, or the Euler equations, in accurate fashion from the microscopic equations of classical mechanics. This book is a valuable resource for mathematicians.

This book will help those wishing to teach a course in technical writing, or who wish to write themselves.

This practical introduction to stochastic reaction-diffusion modelling is based on courses taught at the University of Oxford. The authors discuss the essence of mathematical methods which appear (under different names) in a number of interdisciplinary scientific fields bridging mathematics and computations with biology and chemistry. The book can be used both for self-study and as a supporting text for advanced undergraduate or beginning graduate-level courses in applied mathematics. New mathematical approaches are explained using

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simple examples of biological models, which range in size from simulations of small biomolecules to groups of animals. The book starts with stochastic modelling of chemical reactions, introducing stochastic simulation algorithms and mathematical methods for analysis of stochastic models. Different stochastic spatio-temporal models are then studied, including models of diffusion and stochastic reaction-diffusion modelling. The methods covered include molecular dynamics, Brownian dynamics, velocity jump processes and compartment-based (lattice-based) models.

Mathematics research papers provide a forum for all mathematics enthusiasts to exercise their mathematical experience, expertise and excitement. The research paper process epitomizes the differentiation of instruction, as each student chooses their own topic and extends it as far as their desire takes them. The features and benefits of the research paper process offer a natural alignment with all eight Common Core State Standards for Mathematical Practice. Writing Math Research Papers serves both as a text for students and as a resource for instructors and administrators. It systematically describes the steps involved in creating a mathematics research paper and an oral presentation. The chapters offer tips on technical writing, formatting, and preparing visual aids. For instructors and administrators, the book covers the logistics necessary in setting

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up a mathematics research program in a high school setting. This program received the 1997 Chevron Best Practices in Education Award as the premier high school mathematics course in the United States.

This book provides an introduction to the theory, method, and practice of State-Trace Analysis (STA), and includes a detailed tutorial on the statistical analysis of state-trace designs. The book offers instructions on how to perform state-trace analysis using the authors' own publicly-available software in both Matlab and R. The book begins by discussing the general framework for thinking about the relationships between independent variables, latent variables, and dependent variables. Subsequent chapters provide a software package that can be used to fit state-trace models as well as additional designs and examples. The book concludes with a discussion on potential extensions of STA and additional aspects of its application. State-Trace Analysis will be of interest to researchers and graduate students working in experimental, applied, and cognitive psychology.

This classic guide contains four essays on writing mathematical books and papers at the research level and at the level of graduate texts. The authors are all well known for their writing skills, as well as their mathematical accomplishments. The first essay, by Steenrod, discusses writing books, either monographs or textbooks. He gives both general and specific advice,

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getting into such details as the need for a good introduction. The longest essay is by Halmos, and contains many of the pieces of his advice that are repeated even today: In order to say something well you must have something to say; write for someone; think about the alphabet. Halmos's advice is systematic and practical. Schiffer addresses the issue by examining four types of mathematical writing: research paper, monograph, survey, and textbook, and gives advice for each form of exposition. Dieudonne's contribution is mostly a commentary on the earlier essays, with clear statements of where he disagrees with his coauthors. The advice in this small book will be useful to mathematicians at all levels.

High-dimensional probability offers insight into the behavior of random vectors, random matrices, random subspaces, and objects used to quantify uncertainty in high dimensions. Drawing on ideas from probability, analysis, and geometry, it lends itself to applications in mathematics, statistics, theoretical computer science, signal processing, optimization, and more. It is the first to integrate theory, key tools, and modern applications of high-dimensional probability. Concentration inequalities form the core, and it covers both classical results such as Hoeffding's and Chernoff's inequalities and modern developments such as the matrix Bernstein's inequality. It then introduces the powerful methods based on stochastic processes, including such tools as Slepian's, Sudakov's, and Dudley's inequalities, as well as generic chaining and bounds based on VC dimension. A broad range of illustrations is embedded throughout, including classical and modern results for covariance estimation, clustering, networks, semidefinite programming, coding, dimension reduction, matrix completion, machine learning, compressed sensing, and sparse regression.

Students often need help learning to write well. This book serves as a student text and a

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resource for implementing a mathematics research program. The book details how to write a research paper, from pre-writing to presenting the paper. It provides interesting research topics, a bibliography of periodicals and problem-solving books and information about mathematics contests.

Banish math anxiety and give students of all ages a clear roadmap to success *Mathematical Mindsets* provides practical strategies and activities to help teachers and parents show all children, even those who are convinced that they are bad at math, that they can enjoy and succeed in math. Jo Boaler—Stanford researcher, professor of math education, and expert on math learning—has studied why students don't like math and often fail in math classes. She's followed thousands of students through middle and high schools to study how they learn and to find the most effective ways to unleash the math potential in all students. There is a clear gap between what research has shown to work in teaching math and what happens in schools and at home. This book bridges that gap by turning research findings into practical activities and advice. Boaler translates Carol Dweck's concept of 'mindset' into math teaching and parenting strategies, showing how students can go from self-doubt to strong self-confidence, which is so important to math learning. Boaler reveals the steps that must be taken by schools and parents to improve math education for all. *Mathematical Mindsets*: Explains how the brain processes mathematics learning Reveals how to turn mistakes and struggles into valuable learning experiences Provides examples of rich mathematical activities to replace rote learning Explains ways to give students a positive math mindset Gives examples of how assessment and grading policies need to change to support real understanding Scores of students hate and fear math, so they end up leaving school without an understanding of basic mathematical

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concepts. Their evasion and departure hinders math-related pathways and STEM career opportunities. Research has shown very clear methods to change this phenomena, but the information has been confined to research journals—until now. Mathematical Mindsets provides a proven, practical roadmap to mathematics success for any student at any age.

The Enhancing Diversity in Graduate Education (EDGE) Program began twenty years ago to provide support for women entering doctoral programs in the mathematical sciences. With a steadfast commitment to diversity among participants, faculty, and staff, EDGE initially alternated between Bryn Mawr and Spelman Colleges. In later years, EDGE has been hosted on campuses around the nation and expanded to offer support for women throughout their graduate school and professional careers. The refereed papers in *A Celebration of the EDGE Program's Impact on the Mathematics Community and Beyond* range from short memoirs, to pedagogical studies, to current mathematics research. All papers are written by former EDGE participants, mentors, instructors, directors, and others connected to EDGE. Together, these papers offer compelling testimony that EDGE has produced a diverse new generation of leaders in the mathematics community. This volume contains technical and non-technical works, and it is intended for a far-reaching audience, including mathematicians, mathematics teachers, diversity officers, university administrators, government employees writing educational or science policy, and mathematics students at the high school, college, and graduate levels. By highlighting the scope of the work done by those supported by EDGE, the volume offers strong evidence of the American Mathematical Society's recognition that EDGE is "a program that makes a difference." This volume offers unique testimony that a 20-year old summer program has expanded its reach beyond the summer experience to produce a diverse

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new generation of women leaders, nearly half of whom are underrepresented women. While some books with a women-in-math theme focus only on one topic such as research or work-life balance, this book's broad scope includes papers on mathematics research, teaching, outreach, and career paths.

Discovering Discrete Dynamical Systems is a mathematics textbook designed for use in a student-led, inquiry-based course for advanced mathematics majors. Fourteen modules each with an opening exploration, a short exposition and related exercises, and a concluding project guide students to self-discovery on topics such as fixed points and their classifications, chaos and fractals, Julia and Mandelbrot sets in the complex plane, and symbolic dynamics. Topics have been carefully chosen as a means for developing student persistence and skill in exploration, conjecture, and generalization while at the same time providing a coherent introduction to the fundamentals of discrete dynamical systems. This book is written for undergraduate students with the prerequisites for a first analysis course, and it can easily be used by any faculty member in a mathematics department, regardless of area of expertise. Each module starts with an exploration in which the students are asked an open-ended question. This allows the students to make discoveries which lead them to formulate the questions that will be addressed in the exposition and exercises of the module. The exposition is brief and has been written with the intent that a student who has taken, or is ready to take, a course in analysis can read the material independently. The exposition concludes with exercises which have been designed to both illustrate and explore in more depth the ideas covered in the exposition. Each module concludes with a project in which students bring the ideas from the module to bear on a more challenging or in-depth problem. A section entitled

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"To the Instructor" includes suggestions on how to structure a course in order to realize the inquiry-based intent of the book. The book has also been used successfully as the basis for an independent study course and as a supplementary text for an analysis course with traditional content.

Testimonios brings together first-person narratives from the vibrant, diverse, and complex Latinx and Hispanic mathematical community. Starting with childhood and family, the authors recount their own individual stories, highlighting their upbringing, education, and career paths. Their particular stories, told in their own voices, from their own perspectives, give visibility to some of the experiences of Latinx/Hispanic mathematicians. Testimonios seeks to inspire the next generation of Latinx and Hispanic mathematicians by featuring the stories of people like them, holding a mirror up to our own community. It also aims to provide a window for mathematicians (and aspiring mathematicians) from all ethnicities, with the hope of inspiring a better understanding of the diversity of the mathematical community.

Mathematics research papers provide a forum for all mathematics enthusiasts to exercise their mathematical experience, expertise and excitement. The research paper process epitomizes the differentiation of instruction, as each student chooses their own topic and extends it as far as their motivation and desire takes them. The features and benefits of the research paper process offer a natural alignment with all eight Common Core State Standards for Mathematical Practice. Writing Math Research Papers serves both as a text for students and as a resource for instructors and administrators. The Writing Math Research Papers program started at North Shore High School in 1991, and it received the 1997 Chevron Best Practices in Education Award as the premier high school math course in the United States. Author

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Robert Gerver's articles on high school mathematics research programs were featured in the National Council of Teachers of Mathematics publication *Developing Mathematically Promising Students*, the NCTM's 1999 Yearbook, *Developing Mathematical Reasoning in Grades K – 12*, and in the September 2017 issue of the *Mathematics Teacher*.

Suitable for advanced undergraduates and graduate students of physics, this uniquely comprehensive overview provides a rigorous, integrated treatment of physical principles and techniques related to gases, liquids, solids, and their phase transitions. 1975 edition.

Nick Higham follows up his successful HWMS volume with this much-anticipated second edition.

*How Students Learn: Science in the Classroom* builds on the discoveries detailed in the best-selling *How People Learn*. Now these findings are presented in a way that teachers can use immediately, to revitalize their work in the classroom for even greater effectiveness. Organized for utility, the book explores how the principles of learning can be applied in science at three levels: elementary, middle, and high school. Leading educators explain in detail how they developed successful curricula and teaching approaches, presenting strategies that serve as models for curriculum development and classroom instruction. Their recounting of personal teaching experiences lends strength and warmth to this volume. This book discusses how to build straightforward science experiments into true understanding of scientific principles. It also features illustrated suggestions for classroom activities.

*Systems Factorial Technology: A Theory Driven Methodology for the Identification of Perceptual and Cognitive Mechanisms* explores the theoretical and methodological tools used to investigate fundamental questions central to basic psychological and perceptual processes.

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Such processes include detection, identification, classification, recognition, and decision-making. This book collects the tools that allow researchers to deal with the pervasive model mimicry problems which exist in standard experimental and theoretical paradigms and includes novel applications to not only basic psychological questions, but also clinical diagnosis and links to neuroscience. Researchers can use this book to begin using the methodology behind SFT and to get an overview of current uses and future directions. The collected developments and applications of SFT allow us to peer inside the human mind and provide strong constraints on psychological theory. Provides a thorough introduction to the diagnostic tools offered by SFT Includes a tutorial on applying the method to reaction time data from a variety of different situations Introduces novel advances for testing the significance of SFT results Incorporates new measures that allow for the relaxation of the high accuracy criterion Examines tools to expand the scope of SFT analyses Applies SFT to a spectrum of different cognitive domains across different sensory modalities

"This book is a major treatise in mathematics and is essential in the working library of the modern analyst." (Bulletin of the London Mathematical Society)

The present book contains 20 articles collected from amongst the 53 total submitted manuscripts for the Special Issue "Fuzzy Sets, Fuzzy Logic and Their Applications" of the MDPI journal Mathematics. The articles, which appear in the book in the series in which they were accepted, published in Volumes 7 (2019) and 8 (2020) of the journal, cover a wide range of topics connected to the theory and applications of fuzzy systems and their extensions and generalizations. This range includes, among others, management of the uncertainty in a fuzzy environment; fuzzy assessment methods of human-machine performance; fuzzy graphs; fuzzy

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topological and convergence spaces; bipolar fuzzy relations; type-2 fuzzy; and intuitionistic, interval-valued, complex, picture, and Pythagorean fuzzy sets, soft sets and algebras, etc. The applications presented are oriented to finance, fuzzy analytic hierarchy, green supply chain industries, smart health practice, and hotel selection. This wide range of topics makes the book interesting for all those working in the wider area of Fuzzy sets and systems and of fuzzy logic and for those who have the proper mathematical background who wish to become familiar with recent advances in fuzzy mathematics, which has entered to almost all sectors of human life and activity.

This text offers guidance to teachers, mathematics coaches, administrators, parents, and policymakers. This book: provides a research-based description of eight essential mathematics teaching practices ; describes the conditions, structures, and policies that must support the teaching practices ; builds on NCTM's Principles and Standards for School Mathematics and supports implementation of the Common Core State Standards for Mathematics to attain much higher levels of mathematics achievement for all students ; identifies obstacles, unproductive and productive beliefs, and key actions that must be understood, acknowledged, and addressed by all stakeholders ; encourages teachers of mathematics to engage students in mathematical thinking, reasoning, and sense making to significantly strengthen teaching and learning.

An authorised reissue of the long out of print classic textbook, Advanced Calculus by the late Dr Lynn Loomis and Dr Shlomo Sternberg both of Harvard University has been a revered but hard to find textbook for the advanced calculus course for decades. This

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book is based on an honors course in advanced calculus that the authors gave in the 1960's. The foundational material, presented in the unstarred sections of Chapters 1 through 11, was normally covered, but different applications of this basic material were stressed from year to year, and the book therefore contains more material than was covered in any one year. It can accordingly be used (with omissions) as a text for a year's course in advanced calculus, or as a text for a three-semester introduction to analysis. The prerequisites are a good grounding in the calculus of one variable from a mathematically rigorous point of view, together with some acquaintance with linear algebra. The reader should be familiar with limit and continuity type arguments and have a certain amount of mathematical sophistication. As possible introductory texts, we mention Differential and Integral Calculus by R Courant, Calculus by T Apostol, Calculus by M Spivak, and Pure Mathematics by G Hardy. The reader should also have some experience with partial derivatives. In overall plan the book divides roughly into a first half which develops the calculus (principally the differential calculus) in the setting of normed vector spaces, and a second half which deals with the calculus of differentiable manifolds.

This survey book reviews four interrelated areas: (i) the relevance of heuristics in problem-solving approaches – why they are important and what research tells us about their use; (ii) the need to characterize and foster creative problem-solving approaches – what type of heuristics helps learners devise and practice creative solutions; (iii) the

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importance that learners formulate and pursue their own problems; and iv) the role played by the use of both multiple-purpose and ad hoc mathematical action types of technologies in problem-solving contexts – what ways of reasoning learners construct when they rely on the use of digital technologies, and how technology and technology approaches can be reconciled.

The mathematical sciences are part of nearly all aspects of everyday life-the discipline has underpinned such beneficial modern capabilities as Internet search, medical imaging, computer animation, numerical weather predictions, and all types of digital communications. The Mathematical Sciences in 2025 examines the current state of the mathematical sciences and explores the changes needed for the discipline to be in a strong position and able to maximize its contribution to the nation in 2025. It finds the vitality of the discipline excellent and that it contributes in expanding ways to most areas of science and engineering, as well as to the nation as a whole, and recommends that training for future generations of mathematical scientists should be re-assessed in light of the increasingly cross-disciplinary nature of the mathematical sciences. In addition, because of the valuable interplay between ideas and people from all parts of the mathematical sciences, the report emphasizes that universities and the government need to continue to invest in the full spectrum of the mathematical sciences in order for the whole enterprise to continue to flourish long-term.

``Metric geometry" is an approach to geometry based on the notion of length on a

topological space. This approach experienced a very fast development in the last few decades and penetrated into many other mathematical disciplines, such as group theory, dynamical systems, and partial differential equations. The objective of this graduate textbook is twofold: to give a detailed exposition of basic notions and techniques used in the theory of length spaces, and, more generally, to offer an elementary introduction into a broad variety of geometrical topics related to the notion of distance, including Riemannian and Carnot-Carathéodory metrics, the hyperbolic plane, distance-volume inequalities, asymptotic geometry (large scale, coarse), Gromov hyperbolic spaces, convergence of metric spaces, and Alexandrov spaces (non-positively and non-negatively curved spaces). The authors tend to work with "easy-to-touch" mathematical objects using "easy-to-visualize" methods. The authors set a challenging goal of making the core parts of the book accessible to first-year graduate students. Most new concepts and methods are introduced and illustrated using simplest cases and avoiding technicalities. The book contains many exercises, which form a vital part of the exposition.

Fractional calculus was first developed by pure mathematicians in the middle of the 19th century. Some 100 years later, engineers and physicists have found applications for these concepts in their areas. However there has traditionally been little interaction between these two communities. In particular, typical mathematical works provide extensive findings on aspects with comparatively little significance in applications, and

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the engineering literature often lacks mathematical detail and precision. This book bridges the gap between the two communities. It concentrates on the class of fractional derivatives most important in applications, the Caputo operators, and provides a self-contained, thorough and mathematically rigorous study of their properties and of the corresponding differential equations. The text is a useful tool for mathematicians and researchers from the applied sciences alike. It can also be used as a basis for teaching graduate courses on fractional differential equations.

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