were equally unwelcome. Negatives were thought of as "absurd" and "false" and Cardano remarked that an imaginary number was "as subtle as it is useless."

In the fourth chapter of Pesic's book, he gives sketches of the ingenious proofs of two important results. The first is Newton's argument to show that all simple closed curves have areas that cannot be described by finite algebraic equations and the second is Gauss' proof of the Fundamental Theorem of Algebra.

Pesic then develops the stories of Lagrange and Ruffini. Even after determining that the methods used for solving the cubic and quartic would not work for the quintic, Lagrange continued to believe that it was solvable in radicals. However, Gauss stated in his *Disquisitiones Arithmeticae* that he believed that the quintic had no general radical solution, and Ruffini went so far as to propose six versions of a proof of its unsolvability, although none was completely accepted by the mathematical community.

Finally, in the sixth chapter, we meet Abel and are given a summary of his proof. For those with a larger mathematical appetite, a complete translation of Abel's original 1824 paper is also provided in Appendix A with a commentary by the author. Appendices B and C provide even more details of Abel's 1824 proof. The first explains Abel's argument for the first step, which involves the general form of an algebraic solution. This explanation is based on a paper by Abel from 1826. Appendix C also relies on this paper to elaborate on Cauchy's theorem on permutations, which is also used by Abel in his proof.

We also learn the sad story of Abel's life, his struggle with poverty, and his early death. This story is intertwined with the exciting tale of Galois, who extended and reformulated Abel's results before also meeting an early demise.

Pesic then takes a break from his account to provide the reader with an in-depth analogy of the process of solving equations. He discusses symmetric groups on up to five symbols, connecting them with the Platonic solids and taking care to emphasize the significance of commutativity. The role played by commutativity in the solvability of equations is further explored in the remainder of the book. The reader is left with a summary of the work that has been done since Abel's pivotal result, in particular the determination of the solutions of equations of any degree.

Pesic's book is aimed at a general audience. Mathematical explanations are used only when necessary throughout the story and are easy to follow. Elaborations are provided in boxes for those who are interested, but Pesic insists that these can be "skipped without guilt." The mathematics that does appear is well supported by helpful diagrams. For those wishing to follow up on any of the concepts introduced, Pesic provides notes to each chapter which direct the reader to other useful sources.

As well as containing purely mathematical elements, Pesic's book touches on many other subjects such as music, the history of double-entry bookkeeping, and politics. The book also includes portraits of many of the characters of the story. This complements Pesic's general approach, which is to give the reader a taste of the life of the mathematician whose work he is discussing.

Some readers may wish for more detail about Galois' mathematical contributions, oddly neglected in a work which otherwise does a good job of combining mathematics and biography. In addition, Pesic's decision to interrupt his narrative with a whole chapter devoted to the process of solving equations weakens the suspense that makes the rest of the book such enjoyable reading. Overall though, this is a book well worth the read.

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Felix Hausdorff. Gesammelte Werke. Band II: Grundzüge der Mengenlehre

Edited by Egbert Brieskorn, Srishti D. Chatterji, Moritz Epple, Ulrich Felgner, Horst Herrlich, Mirek Hušek, Vladimir Kanovei, Peter Koepke, Gerhard Preuß, Walter Purkert, and Erhard Scholz. Berlin/Heidelberg/New York (Springer-Verlag). 2002. ISBN 3-540-42224-2. xviii + 884 pp. $87.80

Felix Hausdorff. Gesammelte Werke. Band IV: Analysis, Algebra und Zahlentheorie
Edited by Srishti D. Chatterji, Reinhold Remmert, and Wilfried Scharlau. Berlin/Heidelberg/New York (Springer-Verlag). 2001. ISBN 3-540-41760-5. xix + 554 pp. $65.84

Felix Hausdorff (1868–1942) was a creative and productive mathematician of the first rank. He founded no school and had only a handful of doctoral students, and yet his work in the first third of the 20th century still resonates in the world of mathematics; he is often cited as an early exemplar of the modern mathematician. He was arguably the most prominent mathematical set theorist in the generation after Cantor. He is considered a founder of general topology and an important contributor to descriptive set theory, measure theory, function theory, and functional analysis.

The two books under review certainly bolster the case for these judgments. They are the first two volumes in a project called the Hausdorff Edition. Under the general editorship of E. Brieskorn, F. Hirzebruch, R. Remmert, W. Purkert, and E. Scholz, the Hausdorff Edition, when completed, will consist of nine volumes containing the complete published mathematical works of Felix Hausdorff and some of the philosophical and literary works that he wrote under the pseudonym Paul Mongré. These volumes also include selections of historical and critical interest from Hausdorff's *Nachlaß*, a 26,000-page collection of various unpublished writings housed in the library of the University of Bonn. (The Nachlaß has been cataloged by Walter Purkert, and the catalog—*Findbuch*—is available on line.) All of Hausdorff's publications and the excerpts from his Nachlaß are accompanied by scholarly commentaries that place them in historical context and evaluate their impact on subsequent research; commentaries are usually accompanied by their own list of references.

Hausdorff's classic 1914 text *Grundzüge der Mengenlehre* is the centerpiece of Volume II. It is reprinted with annotations by the editors; some 40 pages of editorial notes appear after the reproduced text. The *Grundzüge* volume begins with an historical introduction by Walter Purkert. In his essay, Purkert makes a convincing case that it was Hausdorff's philosophical-literary alter ego Paul Mongré that led him to Cantor's set theory. Purkert also presents a comparative analysis of the monographs and texts on set theory that preceded *Grundzüge*. A novel inclusion is a 1907 text in Russian by I.I. Shegalkin. The introductory essay ends with a section on the reception and influence of Hausdorff's masterwork.

As for *Grundzüge der Mengenlehre* itself, the first six chapters are devoted to Hausdorff's version of Cantorian set theory as developed through a decade of his own research. They still provide a useful introduction to so-called "naive" set theory. The next three chapters are considered a founding text for general topology. In them Hausdorff uses his set-theoretic viewpoint to generalize the theory of point sets by axiomatizing the concept of neighborhood; he introduces a theory of metric spaces and applies his "topological" approach to the representation of functions. In the final chapter, he gives an elegant presentation of measure theory à la Borel and Lebesgue. In the book's appendix, he sketches his stunning "paradoxical" decomposition of the 2-sphere as the disjoint union of four sets A, B, C, and Q, where Q is countable and the sets A, B, C, and $B \cup C$ are all mutually congruent. This provides a negative solution to a question of Lebesgue on the possible existence in $\mathbb{R}^3$ of a finitely additive, congruence-invariant measure that is defined on all bounded subsets and that takes the value 1 on the unit cube. This decomposition, produced with the aid of the Axiom of Choice, is the immediate inspiration for the famous Banach–Tarski paradoxical decomposition of the unit ball in 3-space.

Eleven commentaries follow the *Grundzüge*. The first three concern the concept of function, the concept of cardinality, and the concept of an η-set. (The η-sets arose from Hausdorff's study of sets of real functions and sequences that were partially ordered by eventual dominance.) These sets have important implications for set theory, topology, algebra, and model theory. The theme then switches to topology with a long essay on the concept of topological space and five shorter notes on particular topological properties such as connectedness and completeness. The last two commentaries concern the subjects of descriptive set theory and measure and integration theory as they appear in *Grundzüge*.

Volume II ends with brief excerpts from Hausdorff's Nachlaß and the reprinting of several contemporary reviews of *Grundzüge der Mengenlehre*. One of the most thoughtful and thorough is Henry Blumberg's review [Blumberg, 1921]. Hausdorff's other published works in set theory will appear in Volumes I and III of the Hausdorff Edition.

Hausdorff considered himself both a set theorist and an analyst. The second volume under review, Volume IV, contains all his published articles in analysis—there are 13—together with 19 excerpts from his Nachlaß. These make up Part I of the volume. Rather than attempt to provide more detail on particular articles, I will just list some of the terms that they have spawned: Hausdorff Paradox, Hausdorff measure, Hausdorff dimension, Hausdorff matrices, Hausdorff summation method, Hausdorff–Toeplitz Theorem, Hausdorff–Young Inequality, Hausdorff moment problem. As for the selections from his Nachlaß, the editors have chosen to highlight his broad interests in analysis and his penchant for surprising counterexamples. One item reveals that Hausdorff discovered the "long line" in 1915, well before its appearance in a paper by P. Alexandroff in 1924. The ultimate selection has no deep mathematical significance, but it is of great poignancy. The calculation of a particular improper integral was produced by Hausdorff at the behest of his son-in-law Arthur König. It is dated January 16, 1942, and it is his last mathematical work. On January 26, 1942, Felix Hausdorff, his wife, and his wife's sister committed suicide when faced with internment at Endenich. Internment was a prelude to deportation to the East and almost certain death.

Parts II and III of Volume IV are devoted to the areas of algebra and number theory, respectively. Three articles appear in the algebra section: the first is a contribution to the study of finite-dimensional associative algebras; the second concerns the exponential formula for Lie algebras, and it establishes the Baker–Campbell–Hausdorff formula; the third concerns what are now called Clifford algebras. A Nachlaß entry on finite commutative rings completes Part II. There is only one article classified as number theory, a simplification of Hilbert's solution of Waring's Problem. Hausdorff's review of Landau's *Handbuch der Lehre von der Verteilung der Primzahlen* [Landau, 1909] is also reprinted in Part III.

The Hausdorff Edition is a very ambitious project. The challenges faced by the editors are clearly illustrated in these two volumes. Felix Hausdorff was a skilled writer. His authorial prowess is quite evident in *Grundzüge der Mengenlehre*. In Volume II, the editors let the text speak for itself. However, their annotations help provide context for today's reader. Walter Purkert's historical introduction and the following commentaries by the editors on set-theoretical and topological concepts help frame *Grundzüge*'s contributions and make manifest the extent of its influence on subsequent generations. In Volume IV, the many separate articles with their focus on specific problems (this being the nature of most research publications) threaten to obscure the overall contribution of this body of work. In this case, the editors have successfully diffused the threat by providing detailed commentaries, usually immediately following a given article; the commentaries do not shy away from clear-eyed judgments of a work's importance and historical significance. Finally, the editors' selections from Felix Hausdorff's Nachlaß help to show what a rich resource this collection promises to be for further scholarly research. These books and all the succeeding volumes of Hausdorff's collected works should be on the shelves of our research libraries.

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Cogwheels of the Mind. The Story of Venn Diagrams

By A.W.F. Edwards. Baltimore and London (The Johns Hopkins University Press). 2004. ISBN 0-8018-7434-3.
xvi + 110 pp. $25

Anthony Edwards has written an engaging, very readable, and profusely illustrated account of the evolution of Venn diagrams from their inception in 1880 to the present day. Containing no fewer than 50 images (nearly all in

Band 5 umfaÃŸt die Themenbereiche Astronomie, Optik und Wahrscheinlichkeitstheorie. Er enthÃ¤lt Hausdorffs Dissertation Ã¼ber die Refraktion des Lichtes in der AtmosphÃ¤re, zwei Folgearbeiten zum gleichen Thema sowie die Habilitationsschrift Ã¼ber die Extinktion des Lichtes in der AtmosphÃ¤re. Es folgt eine Arbeit Ã¼ber geometrische Optik, die unmittelbar an die berÃ¼hmte Publikation von H. Bruns Ã¼ber das Eikonal anschlieÃŸt und in der Hausdorff die damals ganz neuen Lieschen Theorien fÃ¼r die Optik nutzbar zu machen suchte.