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Banach Space Theory Renormings in Banach Spaces An Introduction to Banach Space Theory Analysis in Banach Spaces Probability in Banach Spaces Topics in Banach Space Theory Sequences and Series in Banach Spaces Elements of Geometry of Balls in Banach Spaces Bases in Banach Spaces I Three-space Problems in Banach Space Theory Minimal Projections in Banach Spaces Functional Analysis and Applied Optimization in Banach Spaces Functional Analysis Topics in Banach Space Integration Regularization Methods in Banach Spaces Analysis in Banach Spaces Isometries in Banach Spaces A Basis Theory Primer Handbook of the Geometry of Banach Spaces Geometry and Nonlinear Analysis in Banach Spaces Differentiability in Banach Spaces, Differential Forms and Applications M-Ideals in Banach Spaces and Banach Algebras Probability in Banach Spaces, 8: Proceedings of the Eighth International Conference Geometry and Probability in Banach Spaces Smooth Analysis in Banach Spaces Complex Analysis in Banach Spaces Series in Banach Spaces Bounded Symmetric Domains In Banach Spaces Methods in Banach Space Theory "Ultra"-techniques in Banach Space Theory Fréchet Differentiability of Lipschitz Functions and Porous Sets in Banach Spaces (AM-179) Summing and Nuclear Norms in Banach Space Theory A Short Course on Banach Space Theory Second Order Linear Differential Equations in Banach Spaces Banach Spaces for Analysts General Topology in Banach Spaces Banach Spaces of Analytic Functions Martingales in Banach Spaces Introduction to Various Aspects of Degree Theory in Banach Spaces Introduction to Tensor Products of Banach Spaces

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Handbook of the Geometry of Banach Spaces This text provides the reader with the necessary technical tools and background to reach the frontiers of research without the introduction of too many extraneous concepts. Detailed and accessible proofs are included, as are a variety of exercises and problems. The two new chapters in this second edition are devoted to two topics of much current interest amongst functional analysts: Greedy approximation with respect to bases in Banach spaces and nonlinear geometry of Banach spaces. This new material is intended to present these two directions of research for their intrinsic importance within Banach space theory, and to motivate graduate students interested in learning more about them. This textbook assumes only a basic knowledge of functional analysis, giving the reader a self-contained overview of the ideas and techniques in the development of modern Banach space theory. Special emphasis is placed on the study of the classical Lebesgue spaces Lp (and their sequence space analogues) and spaces of continuous functions. The authors also stress the use of bases and basic sequences techniques as a tool for understanding the isomorphic structure of Banach spaces. From the reviews of the First Edition: "The authors of the book...succeeded admirably in creating a very helpful text, which contains essential topics with optimal proofs, while being reader friendly... It is also written in a lively manner, and its involved mathematical proofs are elucidated and illustrated by motivations, explanations and occasional historical comments... I strongly recommend to every graduate student who wants to get acquainted with this exciting part of functional analysis the instructive and pleasant reading of this book..."—Gilles Godefroy, Mathematical Reviews This volume presents answers to some natural questions of a general analytic character that arise in the theory of Banach spaces. I believe that altogether too many of the results presented herein are unknown to the active abstract analysts, and this is not as it should be. Banach space theory has much to offer the prac titioners of analysis; unfortunately, some of the general principles that motivate the theory and make accessible many of its stunning achievements are couched in the technical jargon of the area, thereby making it unapproachable to one unwilling to spend considerable time and effort in deciphering the jargon. With this in mind, I have concentrated on presenting what I believe are basic phenomena in Banach spaces that any analyst can appreciate, enjoy, and perhaps even use. The topics covered have at least one serious omission: the beautiful and powerful theory of type and cotype. To be quite frank, I could not say what I wanted to say about this subject without increasing the length of the text by at least 75 percent. Even then, the words would not have done as much good as the advice to seek out the rich Seminaire Maurey-Schwartz lecture notes, wherein the theory's development can be traced from its conception. Again, the treasured volumes of Lindenstrauss and Tzafriri also present much of the theory of type and cotype and are must reading for those really interested in Banach space theory. The present volume develops the theory of integration in Banach spaces, martingales and UMD spaces, and culminates in a treatment of the Hilbert transform, Littlewood-Paley theory and the vector-valued Mihlin multiplier theorem. Over the past fifteen years, motivated by regularity problems in evolution equations, there has been tremendous progress in the analysis of Banach space-valued functions and processes. The contents of this extensive and powerful toolbox have been mostly scattered around in research papers and lecture notes. Collecting this diverse body of material into a unified and accessible presentation fills a gap in the existing literature. The principal audience that we have in mind consists of researchers who need and use Analysis in Banach Spaces as a tool for studying problems in partial differential equations, harmonic analysis, and stochastic analysis. Self-contained and offering complete proofs, this work is accessible to graduate students and researchers with a background in functional analysis or related areas. Regularization methods aimed at finding stable approximate solutions are a necessary tool to tackle inverse and ill-posed problems. Usually the mathematical model of an inverse problem consists of an operator equation of the first kind and often the associated forward operator acts between Hilbert spaces. However, for numerous problems the reasons for using a Hilbert space setting seem to be based rather on conventions than on an approprimate and realistic model choice, so often a Banach space setting would be closer to reality. Furthermore, sparsity constraints using general Lp-norms or the BV-norm have recently become very popular. Meanwhile the most well-known methods have been investigated for linear and nonlinear operator equations in Banach spaces. Motivated by these facts the authors aim at collecting and publishing these results in a monograph. This textbook is an introduction to the techniques of summing and nuclear norms. The author's aim is to present a clear and simple account of these ideas and to demonstrate the power of their application to a variety of Banach space questions. The style is expository and the only prerequisite is a beginner's course on Wormed linear spaces and a minimal knowledge of functional analysis. Thus, Dr Jameson is able to concentrate on important, central results and gives concrete and largely non-technical proofs, often supplying alternative proofs which both contribute something to the understanding. Final-year undergraduates and postgraduates in functional analysis will enjoy this introduction to the subject, and there are many examples and exercises throughout the text to help the reader and to demonstrate the range of application these techniques find. A list of references indicates the way for further reading. A powerful introduction to one of the most active areas oftheoretical and applied mathematics This distinctive introduction to one of the most far-reaching andbeautiful areas of mathematics focuses on Banach spaces as themilieu in which most of the fundamental concepts are presented.While occasionally using the more general topological vector spaceand locally convex space setting, it emphasizes the development ofthe reader's mathematical maturity and the ability to bothunderstand and "do" mathematics. In so doing, Functional Analysisprovides a strong springboard for further exploration on the widerange of topics the book presents, including: * Weak topologies and applications * Operators on Banach spaces * Bases in Banach spaces * Sequences, series, and geometry in Banach spaces Stressing the general techniques underlying the proofs, FunctionalAnalysis also features many exercises for immediate clarificationof points under discussion. This thoughtful, well-organizedsynthesis of the work of those mathematicians who created thediscipline of functional analysis as we know it today also providesa rich source of research topics and reference material. Isoperimetric, measure concentration and random process techniques appear at the basis of the modern understanding of Probability in Banach spaces. Based on these tools, the book presents a complete treatment of the main aspects of Probability in Banach spaces (integrability and limit theorems for vector valued random variables, boundedness and continuity of random processes) and of some of their links to Geometry of Banach spaces (via the type and cotype properties). Its purpose is to present some of the main aspects of this theory, from the foundations to the most important achievements. The main features of the investigation are the systematic use of isoperimetry and concentration of measure and abstract random process techniques (entropy and majorizing measures). Examples of these probabilistic tools and ideas to classical Banach space theory are further developed. A comprehensive overview of modern Banach space theory. This book introduces the basic concepts of real and functional analysis. It presents the fundamentals of the calculus of variations, convex analysis, duality, and optimization that are necessary to develop applications to physics and engineering problems. The book includes introductory and advanced concepts in measure and integration, as well as an introduction to Sobolev spaces. The problems presented are nonlinear, with non-convex variational formulation. Notably, the primal global minima may not be attained in some situations, in which cases the solution of the dual problem corresponds to an appropriate weak cluster point of minimizing sequences for the primal one. Indeed, the dual approach more readily facilitates numerical computations for some of the selected models. While intended primarily for applied mathematicians, the text will also be of interest to engineers, physicists, and other researchers in related fields. Second order linear differential equations in Banach spaces can be used for modelling such second order equations of mathematical physics as the wave equation, the Klein-Gordon equation, et al. In this way, a unified treatment can be given to subjects such as growth of solutions, singular perturbation of parabolic, hyperbolic and Schrödinger type initial value problems, and the like. The book covers in detail these subjects as well as the applications to each specific problem. This book makes a significant inroad into the unexpectedly difficult question of existence of Fréchet derivatives of Lipschitz maps of Banach spaces into higher dimensional spaces. Because the question turns out to be closely related to porous sets in Banach spaces, it provides a bridge between descriptive set theory and the classical topic of existence of derivatives of vector-valued Lipschitz functions. The topic is relevant to classical analysis and descriptive set theory on Banach spaces. The book opens several new research directions in this area of geometric nonlinear functional analysis. The new methods developed here include a game approach to perturbational variational principles that is of independent interest. Detailed explanation of the underlying ideas and motivation behind the proofs of the new results on Fréchet differentiability of vector-valued functions should make these arguments accessible to a wider audience. The most important special case of the differentiability results, that Lipschitz mappings from a Hilbert space into the plane have points of Fréchet differentiability, is given its own chapter with a proof that is independent of much of the work done to prove more general results. The book raises several open questions concerning its two main topics. This book is intended to be used with graduate courses in Banach space theory. The development of complex analysis is based on issues related to holomorphic continuation and holomorphic approximation. This volume presents a unified view of these topics in finite and infinite dimensions. A high-level tutorial in pure and applied mathematics, its prerequisites include a familiarity with the basic properties of holomorphic functions, the principles of Banach and Hilbert spaces, and the theory of Lebesgue integration. The four-part treatment begins with an overview of the basic properties of holomorphic mappings and holomorphic domains in Banach spaces. The second section explores differentiable mappings, differentiable forms, and polynomially convex compact sets, in which the results are applied to the study of Banach and Fréchet algebras. Subsequent sections examine plurisubharmonic functions and pseudoconvex domains in Banach spaces, along with Riemann domains and envelopes of holomorphy. In addition to its value as a text for advanced graduate students of mathematics, this volume also functions as a reference for researchers and professionals. Probability limit theorems in infinite-dimensional spaces give conditions un der which convergence holds uniformly over an infinite class of sets or functions. Early results in this direction were the Glivenko-Cantelli, Kolmogorov-Smirnov and Donsker theorems for empirical distribution functions. Already in these cases there is convergence in Banach spaces that are not only infinite-dimensional but nonsep arable. But the theory in such spaces developed slowly until the late 1970's. Meanwhile, work on probability in separable Banach spaces, in relation with the geometry of those spaces, began in the 1950's and developed strongly in the 1960's and 70's. We have in mind here also work on sample continuity and boundedness of Gaussian processes and random methods in harmonic analysis. By the mid-70's a substantial theory was in place, including sharp infinite-dimensional limit theorems under either metric entropy or geometric conditions. Then, modern empirical process theory began to develop, where the collection of half-lines in the line has been replaced by much more general collections of sets in and functions on multidimensional spaces. Many of the main ideas from probability in separable Banach spaces turned out to have one or more useful analogues for empirical processes. Tightness became "asymptotic equicontinuity. " Metric entropy remained useful but also was adapted to metric entropy with bracketing, random entropies, and Kolchinskii-Pollard entropy. Even norms themselves were in some situations replaced by measurable majorants, to which the well-developed separable theory then carried over straightforwardly. This bookis aboutthe subject of higher smoothness in separable real Banach spaces.It brings together several angles of view on polynomials, both in finite and infinite setting.Also a rather thorough and systematic view of the more recent results, and the authors work is given. The book revolves around two main broad questions: What is the best smoothness of a given Banach space, and its structural consequences? How large is a supply of smooth functions in the sense of approximating continuous functions in the uniform topology, i.e. how does the Stone-Weierstrass theorem generalize into infinite dimension where measure and compactness are not available? The subject of infinite dimensional real higher smoothness is treatedherefor the first time in full detail, therefore this book may also serve as a reference book. This timely book exposes succinctly recent advances in the geometric and analytic theory of bounded symmetric domains. A unique feature is the unified treatment of both finite and infinite dimensional symmetric domains, using Jordan theory in tandem with Lie theory. The highlights include a generalized Riemann mapping theorem, which realizes a bounded symmetric domain as the open unit ball of a complex Banach space with a Jordan structure. Far-reaching applications of this realization in complex geometry and function theory are discussed.This monograph is intended as a convenient reference for researchers and graduate students in geometric analysis, infinite dimensional holomorphy as well as functional analysis and operator theory. A continuation of the authors' previous book, Isometries on Banach Spaces: Vector-valued Function Spaces and Operator Spaces, Volume Two covers much of the work that has been done on characterizing isometries on various Banach spaces. Picking up where the first volume left off, the book begins with a chapter on the Banach–Stone property. The authors consider the case where the isometry is from C0(Q, X) to C0(K, Y) so that the property involves pairs (X, Y) of spaces. The next chapter examines spaces X for which the isometries on LP(μ, X) can be described as a generalization of the form given by Lamperti in the scalar case. The book then studies isometries on direct sums of Banach and Hilbert spaces, isometries on spaces of matrices with a variety of norms, and isometries on Schatten classes. It subsequently highlights spaces on which the group of isometries is maximal or minimal. The final chapter addresses more peripheral topics, such as adjoint abelian operators and spectral isometries. Essentially self-contained, this reference explores a fundamental aspect of Banach space theory. Suitable for both experts and newcomers to the field, it offers many references to provide solid coverage of the literature on isometries. This monograph attempts to present the results known today on bases in Banach spaces and some unsolved problems concerning them. Although this important part of the theory of Banach spaces has been studied for more than forty years by numerous mathematicians, the existing books on functional analysis (e. g. M. M. Day [43], A. Wilansky [263], R. E. Edwards [54]) contain only a few results on bases. A survey of the theory of bases in Banach spaces, up to 1963, has been presented in the expository papers [241], [242] and [243], which contain no proofs; although in the meantime the theory has rapidly deve1oped, much of the present monograph is based on those expository papers. Independently, a useful bibliography of papers on bases, up to 1963, was compiled by B. L. Sanders [219J. Due to the vastness of the field, the monograph is divided into two volumes, ofwhich this is the first (see the tab1e of contents). Some results and problems re1ated to those treated herein have been de1iberately planned to be inc1uded in Volume 11, where they will appear in their natural framework (see [242], [243]). This monograph presents an up-to-date panorama of the different techniques and results in the large field of renorming in Banach spaces and its applications. The reader will find a self-contained exposition of the basics on convexity and differentiability, the classical results in building equivalent norms with useful properties, and the evolution of the subject from its origin to the present days. Emphasis is done on the main ideas and their connections. The book covers several goals. First, a substantial part of it can be used as a text for graduate and other advanced courses in the geometry of Banach spaces, presenting results together with proofs, remarks and developments in a structured form. Second, a large collection of recent contributions shows the actual landscape of the field, helping the reader to access the vast existing literature, with hints of proofs and relationships among the different subtopics. Third, it can be used as a reference thanks to comprehensive lists and detailed indices that may lead to expected or unexpected information. Both specialists and newcomers to the field will find this book appealing, since its content is presented in such a way that ready-to-use results may be accessed without going into the details. This flexible approach, from the in-depth reading of a proof to the search for a useful result, together with the fact that recent results are collected here for the first time in book form, extends throughout the book. Open problems and discussions are included, encouraging the advancement of this active area of research. Since its development by Leray and Schauder in the 1930's, degree theory in Banach spaces has proved to be an important tool in tackling many analytic problems, including boundary value problems in ordinary and partial differential equations, integral equations, and eigenvalue and bifurcation problems. With this volume E. H. Rothe provides a largely self-contained introduction to topological degree theory, with an emphasis on its function-analytical aspects. He develops the definition and properties of the degree as much as possible directly in Banach space, without recourse to finite-dimensional theory. A basic tool used is a homotopy theorem for certain linear maps in Banach spaces which allows one to generalize the distinction between maps with positive determinant and those with negative determinant in finite-dimensional spaces. Rothe's book is addressed to graduate students who may have only a rudimentary knowledge of Banach space theory. The first chapter on function-analytic preliminaries provides most of the necessary background. For the benefit of less experienced mathematicians, Rothe introduces the topological tools (subdivision and simplicial approximation, for example) only to the degree of abstraction necessary for the purpose at hand. Readers will gain insight into the various aspects of degree theory, experience in function-analytic thinking, and a theoretic base for applying degree theory to analysis. Rothe describes the various approaches that have historically been taken towards degree theory, making the relationships between these approaches clear. He treats the differential method, the simplicial approach introduced by Brouwer in 1911, the Leray-Schauder method (which assumes Brouwer's degree theory for the finite-dimensional space and then uses a limit process in the dimension), and attempts to establish degree theory in Banach spaces intrinsically, by an application of the differential method in the Banach space case. Publisher Description This is the first ever truly introductory text to the theory of tensor products of Banach spaces. Coverage includes a full treatment of the Grothendieck theory of tensor norms, approximation property and the Radon-Nikodym Property, Bochner and Pettis integrals. Each chapter contains worked examples and a set of exercises, and two appendices offer material on summability in Banach spaces and properties of spaces of measures. This second volume of Analysis in Banach Spaces, Probabilistic Methods and Operator Theory, is the successor to Volume I, Martingales and Littlewood-Paley Theory. It presents a thorough study of the fundamental randomisation techniques and the operator-theoretic aspects of the theory. The first two chapters address the relevant classical background from the theory of Banach spaces, including notions like type, cotype, K-convexity and contraction principles. In turn, the next two chapters provide a detailed treatment of the theory of R-boundedness and Banach space valued square functions developed over the last 20 years. In the last chapter, this content is applied to develop the holomorphic functional calculus of sectorial and bi-sectorial operators in Banach spaces. Given its breadth of coverage, this book will be an invaluable reference to graduate students and researchers interested in functional analysis, harmonic analysis, spectral theory, stochastic analysis, and the operator-theoretic approach to deterministic and stochastic evolution equations. Banach spaces provide a framework for linear and nonlinear functional analysis, operator theory, abstract analysis, probability, optimization and other branches of mathematics. This book introduces the reader to linear functional analysis and to related parts of infinite-dimensional Banach space theory. Key Features: - Develops classical theory, including weak topologies, locally convex space, Schauder bases and compact operator theory - Covers Radon-Nikodým property, finite-dimensional spaces and local theory on tensor products - Contains sections on uniform homeomorphisms and non-linear theory, Rosenthal's L1 theorem, fixed points, and more - Includes information about further topics and directions of research and some open problems at the end of each chapter - Provides numerous exercises for practice The text is suitable for graduate courses or for independent study. Prerequisites include basic courses in calculus and linear. Researchers in functional analysis will also benefit for this book as it can serve as a reference book. The relatively new concepts of the Henstock-Kurzweil and McShane integrals based on Riemann type sums are an interesting challenge in the study of integration of Banach space-valued functions. This timely book presents an overview of the concepts developed and results achieved during the past 15 years. The Henstock-Kurzweil and McShane integrals play the central role in the book. Various forms of the integration are introduced and compared from the viewpoint of their generality. Functional analysis is the main tool for presenting the theory of summation gauge integrals. One of the subjects of functional analysis is classification of Banach spaces depending on various properties of the unit ball. The need of such considerations comes from a number of applications to problems of mathematical analysis. The list of subjects includes: differential calculus in normed spaces, approximation theory, weak topologies and reflexivity, general theory of convexity and convex functions, metric fixed point theory and others. The book presents basic facts from this field. This book focuses on applications of martingales to the geometry of Banach spaces, and is accessible to graduate students. This textbook is a self-contained introduction to the abstract theory of bases and redundant frame expansions and their use in both applied and classical harmonic analysis. The four parts of the text take the reader from classical functional analysis and basis theory to modern time-frequency and wavelet theory. Extensive exercises complement the text and provide opportunities for learning-by-doing, making the text suitable for graduate-level courses. The self-contained presentation with clear proofs is accessible to graduate students, pure and applied mathematicians, and engineers interested in the mathematical underpinnings of applications. A classic of pure mathematics, this advanced graduate-level text explores the intersection of functional analysis and analytic function theory. Close in spirit to abstract harmonic analysis, it is confined to Banach spaces of analytic functions in the unit disc. The author devotes the first four chapters to proofs of classical theorems on boundary values and boundary integral representations of analytic functions in the unit disc, including generalizations to Dirichlet algebras. The fifth chapter contains the factorization theory of Hp functions, a discussion of some partial extensions of the factorization, and a brief description of the classical approach to the theorems of the first five chapters. The remainder of the book addresses the structure of various Banach spaces and Banach algebras of analytic functions in the unit disc. Enhanced with 100 challenging exercises, a bibliography, and an index, this text belongs in the libraries of students, professional mathematicians, as well as anyone interested in a rigorous, high-level treatment of this topic. This book provides a comprehensive exposition of M-ideal theory, a branch ofgeometric functional analysis which deals with certain subspaces of Banach spaces arising naturally in many contexts. Starting from the basic definitions the authors discuss a number of examples of M-ideals (e.g. the closed two-sided ideals of C*-algebras) and develop their general theory. Besides, applications to problems from a variety of areas including approximation theory, harmonic analysis, C*-algebra theory and Banach space geometry are presented. The book is mainly intended as a reference volume for researchers working in one of these fields, but it also addresses students at the graduate or postgraduate level. Each of its six chapters is accompanied by a Notes-and-Remarks section which explores further ramifications of the subject and gives detailed references to the literature. An extensive bibliography is included. Series of scalars, vectors, or functions are among the fundamental objects of mathematical analysis. When the arrangement of the terms is fixed, investigating a series amounts to investigating the sequence of its partial sums. In this case the theory of series is a part of the theory of sequences, which deals with their convergence, asymptotic behavior, etc. The specific character of the theory of series manifests itself when one considers rearrangements (permutations) of the terms of a series, which brings combinatorial considerations into the problems studied. The phenomenon that a numerical series can change its sum when the order of its terms is changed is one of the most impressive facts encountered in a university analysis course. The present book is devoted precisely to this aspect of the theory of series whose terms are elements of Banach (as well as other topological linear) spaces. The exposition focuses on two complementary problems. The first is to char acterize those series in a given space that remain convergent (and have the same sum) for any rearrangement of their terms; such series are usually called uncon ditionally convergent. The second problem is, when a series converges only for certain rearrangements of its terms (in other words, converges conditionally), to describe its sum range, i.e., the set of sums of all its convergent rearrangements. This book is divided into two parts, the first one to study the theory of differentiable functions between Banach spaces and the second to study the differential form formalism and to address the Stokes' Theorem and its applications. Related to the first part, there is an introduction to the content of Linear Bounded Operators in Banach Spaces with classic examples of compact and Fredholm operators, this aiming to define the derivative of Fréchet and to give examples in Variational Calculus and to extend the results to Fredholm maps. The Inverse Function Theorem is explained in full details to help the reader to understand the proof details and its motivations. The inverse function theorem and applications make up this first part. The text contains an elementary approach to Vector Fields and Flows, including the Frobenius Theorem. The Differential Forms are introduced and applied to obtain the Stokes Theorem and to define De Rham cohomology groups. As an application, the final chapter contains an introduction to the Harmonic Functions and a geometric approach to Maxwell's equations of electromagnetism. This book on Banach space theory focuses on what have been called three-space problems. It contains a fairly complete description of ideas, methods, results and counterexamples. It can be considered self-contained, beyond a course in functional analysis and some familiarity with modern Banach space methods. It will be of interest to researchers for its methods and open problems, and to students for the exposition of techniques and examples. Preparing students for further study of both the classical works and current research, this is an accessible text for students who have had a course in real and complex analysis and understand the basic properties of L p spaces. It is sprinkled liberally with examples, historical notes, citations, and original sources, and over 450 exercises provide practice in the use of the results developed in the text through supplementary examples and counterexamples.