Lecture Notes On Functional Analysis With Applications To Linear Partial Differential Equations Graduate Studies In Mathematics

Since its first appearance as a set of lecture notes published by the Courant Institute in 1974, this book served as an introduction to various subjects in nonlinear functional analysis. The current edition is a reprint of these notes, with added bibliographic references. Topological and analytic methods are developed for treating nonlinear ordinary and partial differential equations. The first two chapters of the book introduce the notion of topological degree and develop its basic properties. These properties are used in later chapters in the discussion of bifurcation theory (the possible branching of solutions as parameters vary), including the proof of Rabinowitz global bifurcation theorem. Stability of the branches is also studied. The book concludes with a presentation of some generalized implicit function theorems of Nash-Moser type with applications to Kolmogorov-Arnold-Moser theory and to conjugacy problems. For more than 20 years, this book continues to be an excellent graduate level textbook and a useful supplementary course text. Titles in this series are copublished with the Courant Institute of Mathematical Sciences at New York University.

These notes are a record of a one semester course on Functional Analysis given by the author to second year Master of Statistics students at the Indian Statistical Institute, New Delhi. Students taking this course have a strong background in real analysis, linear algebra, measure theory and probability, and the course proceeds rapidly from the definition of a normed linear space to the spectral theorem for bounded selfadjoint operators in a Hilbert space. The book is organised as twenty six lectures, each corresponding to a ninety minute class session. This may be helpful to teachers planning a course on this topic. Well prepared students can read it on their own.

This volume consists of a long monographic paper by J. Hoffmann-Jorgensen and a number of shorter research papers and survey articles covering different aspects of functional analysis and its application to probability theory and differential equations.

Accessible text covering core functional analysis topics in Hilbert and Banach spaces, with detailed proofs and 200 fully-worked exercises.

Elementary Functional Analysis

Israel Seminar 2006–2010

Introduction to Functional Analysis

Functional analysis. I

Geometric Aspects of Functional Analysis

These proceedings from the Symposium on Functional Analysis explore advances in the usually separate areas of semigroups of operators and evolution equations, geometry of Banach spaces and operator ideals, and Frechet spaces with applications in partial differential equations.

This book provides an introduction to the ideas and methods of linear func tional analysis at a level appropriate to the final year of an undergraduate course at a British university. The prerequisites for reading it are a standard undergraduate knowledge of linear algebra and real analysis (including the the ory of metric spaces). Part of the development of functional analysis can be traced to attempts to find a suitable framework in which to discuss differential and integral equa tions. Often, the appropriate setting turned out to be a vector space of real or complex-valued functions defined on some set. In general, such a vector space is infinite-dimensional. This leads to difficulties in that, although many of the elementary properties of finite-dimensional vector spaces hold in infinite dimensional vector spaces, many others do not. For example, in general infinite dimensional vector spaces there is no framework in which to make sense of an alytic concepts such as convergence and continuity. Nevertheless, on the spaces of most interest to us there is often a norm (which extends the idea of the length of a vector to a somewhat more abstract setting). Since a norm on a vector space gives rise to a metric on the space, it is now possible to do analysis in the space. As real or complex-valued functions are often called functionals, the term functional analysis came to be used for this topic. We now briefly outline the contents of the book.

This textbook is addressed to graduate students in mathematics or other disciplines who wish to understand the essential concepts of functional analysis and their applications to partial differential equations. The book is intentionally concise, presenting all the fundamental concepts and results but omitting the more specialized topics. Enough of the theory of Sobolev spaces and semigroups of linear operators is included as needed to develop significant applications to elliptic, parabolic, and hyperbolic PDEs. Throughout the book, care has been taken to explain the connections between theorems in functional analysis and familiar results of finite-dimensional linear algebra. The main concepts and ideas used in the proofs are illustrated with a large number of figures. A rich collection of homework problems is included at the end of most chapters. The book is suitable as a text for a one-semester graduate course.

Developed over years of classroom use, this textbook provides a clear and accessible approach to real analysis. This modern

interpretation is based on the author's lecture notes and has been meticulously tailored to motivate students and inspire readers to explore the material, and to continue exploring even after they have finished the book. The definitions, theorems, and proofs contained within are presented with mathematical rigor, but conveyed in an accessible manner and with language and motivation meant for students who have not taken a previous course on this subject. The text covers all of the topics essential for an introductory course, including Lebesgue measure, measurable functions, Lebesgue integrals, differentiation, absolute continuity, Banach and Hilbert spaces, and more. Throughout each chapter, challenging exercises are presented, and the end of each section includes additional problems. Such an inclusive approach creates an abundance of opportunities for readers to develop their understanding, and aids instructors as they plan their coursework. Additional resources are available online, including expanded chapters, enrichment exercises, a detailed course outline, and much more. Introduction to Real Analysis is intended for first-year graduate students taking a first course in real analysis, as well as for instructors seeking detailed lecture material with structure and accessibility in mind. Additionally, its content is appropriate for Ph.D. students in any scientific or engineering discipline who have taken a standard upper-level undergraduate real analysis course.

Functional Analysis, Spectral Theory, and Applications

Interaction Between Functional Analysis, Harmonic Analysis, and Probability

Introduction to Real Analysis

Lectures on Functional Analysis: Perturbation by bounded operators

From Hahn-Banach to Monotonicity

This book started its life as a series of lectures given by the second author from the 1970's onwards to students in their third and fourth years in the Department of Mechanics and Mathematics at Rostov State University. For these lectures there was also an audience of engineers and applied mechanicists who wished to understand the functional analysis used in contemporary research in their fields. These people were not so much interested in functional analysis itself as in its applications; they did not want to be told about functional analysis in its most abstract form, but wanted a guided tour through those parts of the analysis needed for their applications. The lecture notes evolved over the years as the first author started to make more formal typewritten versions incorporating new material. About 1990 the first author prepared an English version and submitted it to Kluwer Academic Publishers for inclusion in the series Solid Mechanics and its Applications. At that state the notes were divided into three long chapters covering linear and nonlinear analysis. As Series Editor, the third author started to edit them. The requirements of lecture notes and books are vastly different. A book has to be complete (in some sense), self contained, and able to be read without the help of an instructor.

While there is a plethora of excellent, but mostly "tell-it-all'' books on the subject, this one is intended to take a unique place in what today seems to be a still wide open niche for an introductory text on the basics of functional analysis to be taught within the existing constraints of the standard, for the United States, one-semester graduate curriculum (fifteen weeks with two seventy-five-minute lectures per week). The book consists of seven chapters and an appendix taking the reader from the fundamentals of abstract spaces (metric, vector, normed vector, and inner product), through the basics of linear operators and functionals, the three fundamental principles (the Hahn-Banach Theorem, the Uniform Boundedness Principle, the Open Mapping Theorem and its equivalents: the Inverse Mapping and Closed Graph Theorems) with their numerous profound implications and certain interesting applications, to the elements of the duality and reflexivity theory. Chapter 1 outlines some necessary preliminaries, while the Appendix gives a concise discourse on the celebrated Axiom of Choice, its equivalents (the Hausdorff Maximal Principle, Zorn's Lemma, and Zermello's Well-Ordering Principle), and ordered sets. Being designed as a text to be used in a classroom, the book constantly calls for the student's actively mastering the knowledge of the subject matter. It contains 112 Problems, which are indispensable for understanding and moving forward. Many important statements are given as problems, a lot of these are frequently referred to and used in the main body. There are also 376 Exercises throughout the text, including Chapter 1 and the Appendix, which require of the student to prove or verify a statement or an example, fill in necessary details in a proof, or provide an intermediate step or a counterexample. They are also an inherent part of the material. More difficult problems are marked with an asterisk, many problem and exercises being supplied with "existential'' hints. The book is generous on Examples and contains numerous Remarks accompanying every definition and virtually each statement to discuss certain subtleties, raise questions on whether the converse assertions are true, whenever appropriate, or whether the conditions are essential. The prerequisites are set intentionally quite low, the students not being assumed to have taken graduate courses in real or complex analysis and general topology, to make the course accessible and attractive to a wider audience of STEM (science, technology, engineering, and mathematics) graduate students or advanced undergraduates with a solid background in calculus and linear algebra. With proper attention given to applications, plenty of examples, problems, and exercises, this well-designed text is ideal for a one-semester graduate course on the fundamentals of functional analysis for students in mathematics, physics, computer science, and engineering. ContentsPreliminariesMetric SpacesNormed Vector and Banach SpacesInner Product and Hilbert SpacesLinear Operators and FunctionalsThree Fundamental Principles of Linear Functional AnalysisDuality and ReflexivityThe Axiom of Choice and Equivalents

Even the simplest mathematical abstraction of the phenomena of reality the real line-can be regarded from different points of view by different mathematical disciplines. For example, the algebraic approach to the study of the real line involves describing its properties as a set to whose elements we can apply" operations," and obtaining an algebraic model of it on the basis of these properties, without regard for the topological properties. On the other hand, we can focus on the topology of the real line and construct a formal model of it by singling out its" continuity" as a basis for the model. Analysis regards the line, and the functions on it, in the unity of the whole system of their algebraic and topological properties, with the fundamental deductions about them obtained by using the interplay between the algebraic and topological structures. The same picture is observed at higher stages of abstraction. Algebra studies linear spaces, groups, rings, modules, and so on. Topology studies structures of a different kind on arbitrary sets, structures that give mathe matical meaning to the concepts of a limit, continuity, a neighborhood, and so on. Functional analysis takes up topological linear spaces, topological groups, normed rings, modules of representations of topological groups in topological linear spaces, and so on. Thus, the basic object of study in functional analysis consists of objects equipped with compatible algebraic and topological structures.
From the Contents: A. Lambert: Weighted shifts and composition operators on L2; - A.S.Cavaretta/A.Sharma: Variation diminishing properties and convexityfor the tensor product Bernstein operator; - B.P. Duggal: A note on generalised commutativity theorems in the Schatten norm; - B.S.Yadav/D.Singh/S.Agrawal: De Branges Modules in H2(Ck) of the torus; - D. Sarason: Weak compactness of holomorphic composition operators on H1; - H.Helson/J.E.McCarthy: Continuity of seminorms; - J.A. Siddiqui: Maximal ideals in local Carleman algebras; - J.G. Klunie: Convergence of polynomials with restricted zeros; - J.P. Kahane: On a theorem of Polya; - U.N. Singh: The Carleman-Fourier transform and its applications; - W. Zelasko: Extending seminorms in locally pseudoconvex algebras.
Introductory Functional Analysis with Applications
With Applications to Linear Partial Differential Equations
Real and Abstract Analysis
Lecture Notes on Elementary Topology and Geometry
Functional Analysis

This book gives the basis of the probabilistic functional analysis on Wiener space, developed during the last decade. The subject has progressed considerably in recent years thr- ough its links with QFT and the impact of Stochastic Calcu- lus of Variations of P. Malliavin. Although the latter deals essentially with the regularity of the laws of random varia- bles defined on the Wiener space, the book focuses on quite different subjects, i.e. independence, Ramer's theorem, etc. First year graduate level in functional analysis and theory of stochastic processes is required (stochastic integration with respect to Brownian motion, Ito formula etc). It can be taught as a 1-semester course as it is, or in 2 semesters adding preliminaries from the theory of stochastic processes It is a user-friendly introduction to Malliavin calculus!

This book provides readers with a concise introduction to current studies on operator-algebras and their generalizations, operator spaces and operator systems, with a special focus on their application in quantum information science. This basic framework for the mathematical formulation of quantum information can be traced back to the mathematical work of John von Neumann, one of the pioneers of operator algebras, which forms the underpinning of most current mathematical treatments of the quantum theory, besides being one of the most dynamic areas of twentieth century functional analysis. Today, von Neumann's foresight finds expression in the rapidly growing field of quantum information theory. These notes gather the content of lectures given by a very distinguished group of mathematicians and quantum information theorists, held at the IMSc in Chennai some years ago, and great care has been taken to present the material as a primer on the subject matter. Starting from the basic definitions of operator spaces and operator systems, this text proceeds to discuss several important theorems including Stinespring's dilation theorem for completely positive maps and Kirchberg's theorem on tensor products of C-algebras. It also takes a closer look at the abstract characterization of operator systems and, motivated by the requirements of different tensor products in quantum information theory, the theory of tensor products in operator systems is discussed in detail. On the quantum information side, the book offers a rigorous treatment of quantifying entanglement in bipartite quantum systems, and moves on to review four different areas in which ideas from the theory of operator systems and operator algebras play a natural role: the issue of zero-error communication over quantum channels, the strong subadditivity property of quantum entropy, the different norms on quantum states and the corresponding induced norms on quantum channels, and, lastly, the applications of matrix-valued random variables in the quantum information setting.*

This new edition of LNM 1693 aims to reduce questions on monotone multifunctions to questions on convex functions. However, rather than using a "big convexification" of the graph of the multifunction and the "minimax technique" for proving the existence of linear functionals satisfying certain conditions, the Fitzpatrick function is used. The journey begins with the Hahn-Banach theorem and culminates in a survey of current results on monotone multifunctions on a Banach space.

This book is based on lectures presented over many years to second and third year mathematics students in the Mathematics Departments at Bedford College, London, and King's College, London, as part of the BSc. and MSci. program. Its aim is to provide a gentle yet rigorous first course on complex analysis.Metric space aspects of the complex plane are discussed in detail, making this text an excellent introduction to metric space theory. The complex exponential and trigonometric functions are defined from first principles and great care is taken to derive their familiar properties. In particular, the appearance of π, in this context, is carefully explained.The central results of the subject, such as Cauchy's Theorem and its immediate corollaries, as well as the theory of singularities and the Residue Theorem are carefully treated while avoiding overly complicated generality. Throughout, the theory is illustrated by examples.A number of relevant results from real analysis are collected, complete with proofs, in an appendix.The approach in this book attempts to soften the impact for the student who may feel less than completely comfortable with the logical but often overly concise presentation of mathematical analysis elsewhere.

Nonlinear Functional Analysis

The Functional Analysis of Quantum Information Theory
Functional Analysis II
Spectral Analysis on Graph-like Spaces

This book is based on the lectures presented at the Special Session on Nonlinear Functional Analysis of the American Mathematical Society Regional Meeting, held at New Jersey Institute of Technology. It explores global invertibility and finite solvability of nonlinear differential equations.

This textbook provides a careful treatment of functional analysis and some of its applications in analysis, number theory, and ergodic theory. In addition to discussing core material in functional analysis, the authors cover more recent and advanced topics, including Weyl ' s law for eigenfunctions of the Laplace operator, amenability and property (T), the measurable functional calculus, spectral theory for unbounded operators, and an account of Tao ' s approach to the prime number theorem using Banach algebras. The book further contains numerous examples and exercises, making it suitable for both lecture courses and self-study. Functional Analysis, Spectral Theory, and Applications is aimed at postgraduate and advanced undergraduate students with some background in analysis and algebra, but will also appeal to everyone with an interest in seeing how functional analysis can be applied to other parts of mathematics.

It begins in Chapter 1 with an introduction to the necessary foundations, including the Arzel à – Ascoli theorem, elementary Hilbert space theory, and the Baire Category Theorem. Chapter 2 develops the three fundamental principles of functional analysis (uniform boundedness, open mapping theorem, Hahn – Banach theorem) and discusses reflexive spaces and the James space. Chapter 3 introduces the weak and weak topologies and includes the theorems of Banach – Alaoglu, Banach – Dieudonn é , Eberlein – Š mulyan, Kre&ibreve;n – Milman, as well as an introduction to topological vector spaces and applications to ergodic theory. Chapter 4 is devoted to Fredholm theory. It includes an introduction to the dual operator and to compact operators, and it establishes the closed image theorem. Chapter 5 deals with the spectral theory of bounded linear operators. It introduces complex Banach and Hilbert spaces, the continuous functional calculus for self-adjoint and normal operators, the Gelfand spectrum, spectral measures, cyclic vectors, and the spectral theorem. Chapter 6 introduces unbounded operators and their duals. It establishes the closed image theorem in this setting and extends the functional calculus and spectral measure to unbounded self-adjoint operators on Hilbert spaces. Chapter 7 gives an introduction to strongly continuous semigroups and their infinitesimal generators. It includes foundational results about the dual semigroup and analytic semigroups, an exposition of measurable functions with values in a Banach space, and a discussion of solutions to the inhomogeneous equation and their regularity properties. The appendix establishes the equivalence of the Lemma of Zorn and the Axiom of Choice, and it contains a proof of Tychonoff's theorem. With 10 to 20 elaborate exercises at the end of each chapter, this book can be used as a text for a one-or-two-semester course on functional analysis for beginning graduate students. Prerequisites are first-year analysis and linear algebra, as well as some foundational material from the second-year courses on point set topology, complex analysis in one variable, and measure and integration.

Small-radius tubular structures have attracted considerable attention in the last few years, and are frequently used in different areas such as Mathematical Physics, Spectral Geometry and Global Analysis. In this monograph, we analyse Laplace-like operators on thin tubular structures ("graph-like spaces''), and their natural limits on metric graphs. In particular, we explore norm resolvent convergence, convergence of the spectra and resonances. Since the underlying spaces in the thin radius limit change, and become singular in the limit, we develop new tools such as norm convergence of operators acting in different Hilbert spaces, an extension of the concept of boundary triples to partial differential operators, and an abstract definition of resonances via boundary triples. These tools are formulated in an abstract framework, independent of the original problem of graph-like spaces, so that they can be applied in many other situations where the spaces are perturbed.

Functional Analysis and Operator Theory

Lecture Notes on Functional Analysis

Stochastic Processes and Functional Analysis

Topics in Functional Analysis

Israel Seminar (GAFA) 2017-2019 Volume I

At the present time, the average undergraduate mathematics major finds mathematics heavily compartmentalized. After the calculus, he takes a course in analysis and a course in algebra. Depending upon his interests (or those of his department), he takes courses in special topics. Ifhe is exposed to topology, it is usually straightforward point set topology; if he is exposed to geom etry, it is usually classical differential geometry. The exciting revelations that there is some unity in mathematics, that fields overlap, that techniques of one field have applications in another, are denied the undergraduate. He must wait until he is well into graduate work to see interconnections, presumably because earlier he doesn't know enough. These notes are an attempt to break up this compartmentalization, at least in topology-geometry. What the student has learned in algebra and advanced calculus are used to prove some fairly deep results relating geometry, topol ogy, and group theory. (De Rham's theorem, the Gauss-Bonnet theorem for surfaces, the functorial relation of fundamental group to covering space, and surfaces of constant curvature as homogeneous spaces are the most note worthy examples.) In the first two chapters the bare essentials of elementary point set topology are set forth with some hint ofthe subject's application to functional analysis.

The electronic Schrodi ? nger equation describes the motion of N electrons under Coulomb interaction forces in a eld of clamped nuclei. Solutions of this equation depend on 3N variables, three spatial dimensions for each electron. Approxim- ing the solutions is thus inordinately challenging, and it is conventionally believed that a reduction to simpli ed models, such as those of the Hartree-Fock method or density functional theory, is the only tenable approach. This book seeks to c- vince the reader that this conventional wisdom need not be ironclad: the regularity of the solutions, which increases with the number of electrons, the decay behavior of their mixed derivatives, and the antisymmetry enforced by the Pauli principle contribute properties that allow these functions to be approximated with an order of complexity which comes arbitrarily close to that for a system of one or two electrons. The present notes arose from lectures that I gave in Berlin during the academic year 2008/09 to introduce beginning graduate students of mathematics into this subject. They are kept on an intermediate level that should be accessible to an audience of this kind as well as to physicists and theoretical chemists with a c- responding mathematical training.

Includes sections on the spectral resolution and spectralrepresentation of self adjoint operators, invariant subspaces,strongly continuous one-parameter semigroups, the index ofoperators, the trace formula of Lidskii, the Fredholm determinant,and more. * Assumes prior knowledge of Naive set theory, linear algebra,point set topology, basic complex variable, and realvariables. * Includes an appendix on the Riesz representation theorem.

Designed for undergraduate mathematics majors, this self-contained exposition of Gelfand's proof of Wiener's theorem explores set theoretic preliminaries, normed linear spaces and algebras, functions on Banach spaces, homomorphisms on normed linear spaces, and more. 1966 edition.

Proceedings of a Conference held in Memory of U.N.Singh, New Delhi, India, 2-6 August, 1990

Applied Functional Analysis

A modern treatment of the theory of functions of a real variable

p-adic Functional Analysis

Linear Functional Analysis

This collection of original papers related to the Israeli GAFA seminar (on Geometric Aspects of Functional Analysis) from the years 2006 to 2011 continues the long tradition of the previous volumes, which reflect the general trends of Asymptotic Geometric Analysis, understood in a broad sense, and are a source of inspiration for new research. Most of the papers deal with various aspects of the theory, including classical topics in the geometry of convex bodies, inequalities involving volumes of such bodies or more generally, logarithmically-concave measures, valuation theory, probabilistic and isoperimetric problems in the combinatorial setting, volume distribution on high-dimensional spaces and characterization of classical constructions in Geometry and Analysis (like the Legendre and Fourier transforms, derivation and others). All the papers here are original research papers.

Based on a conference on the interaction between functional analysis, harmonic analysis and probability theory, this work offers discussions of each distinct field, and integrates points common to each. It examines developments in Fourier analysis, interpolation theory, Banach space theory, probability, probability in Banach spaces, and more.

"Contains research articles by nearly 40 leading mathematicians from North and South America, Europe, Africa, and Asia, presented at the Fourth International Conference on p-adic Functional Analysis held recently in Nijmegen, The Netherlands. Includes numerous new open problems documented with extensive comments and references."

This extraordinary compilation is an expansion of the recent American Mathematical Society Special Session celebrating M. M. Rao's distinguished career and includes most of the presented papers as well as ancillary contributions from session invitees. This book shows the effectiveness of abstract analysis for solving fundamental problems of stochas

A Volume of Recent Advances in Honor of M. M. Rao

An Introduction to Functional Analysis

Topics in Nonlinear Functional Analysis

Theorems and Problems in Functional Analysis

Applications in Mechanics and Inverse Problems

Lecture Notes on Functional AnalysisWith Applications to Linear Partial Differential EquationsAmerican Mathematical Soc.

Continuing the theme of the previous volumes, these seminar notes reflect general trends in the study of Geometric Aspects of Functional Analysis, understood in a broad sense. Two classical topics represented are the Concentration of Measure Phenomenon in the Local Theory of Banach Spaces, which has recently had triumphs in Random Matrix Theory, and the Central Limit Theorem, one of the earliest examples of regularity and order in high dimensions. Central to the text is the study of the Poincaré and log-Sobolev functional inequalities, their reverses, and other inequalities, in which a crucial role is often played by convexity assumptions such as Log-Concavity. The concept and properties of Entropy form an important subject, with Bourgain's slicing problem and its variants drawing much attention. Constructions related to Convexity Theory are proposed and revisited, as well as inequalities that go beyond the Brunn–Minkowski theory. One of the major current research directions addressed is the identification of lower-dimensional structures with remarkable properties in rather arbitrary high-dimensional objects. In addition to functional analytic results, connections to Computer Science and to Differential Geometry are also discussed.

The text contains for the first time in book form the state of the art of homological methods in functional analysis like characterizations of the vanishing of the derived projective limit functor or the functors Ext1 (E, F) for Fréchet and more general spaces. The researcher in real and complex analysis finds powerful tools to solve surjectivity problems e.g. on spaces of distributions or to characterize the existence of solution operators. The requirements from homological algebra are minimized: all one needs is summarized on a few pages. The answers to several questions of V.P. Palamodov who invented homological methods in analysis also show the limits of the program.

This compact textbook is a collection of the author’s lecture notes for a two-semester graduate-level real analysis course. While the material covered is standard, the author’s approach is unique in that it combines elements from both Royden’s and Folland’s classic texts to provide a more concise and intuitive presentation. Illustrations, examples, and exercises are included that present Lebesgue integrals, measure theory, and topological spaces in an original and more accessible way, making difficult concepts easier for students to understand. This text can be used as a supplementary resource or for individual study.

Applications to Mathematical Physics

A Collection of Notes Based on Lectures by Gilles Pisier, K. R. Parthasarathy, Vern Paulsen and Andreas Winter
Lecture Notes On Complex Analysis
An Introduction to Analysis on Wiener Space
Notes on Functional Analysis

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This book is first of all designed as a text for the course usually called "theory of functions of a real variable". This course is at present cus tomarily offered as a first or second year graduate course in United States universities, although there are signs that this sort of analysis will soon penetrate upper division undergraduate curricula. We have included every topic that we think essential for the training of analysts, and we have also gone down a number of interesting bypaths. We hope too that the book will be useful as a reference for mature mathematicians and other scientific workers. Hence we have presented very general and complete versions of a number of important theorems and constructions. Since these sophisticated versions may be difficult for the beginner, we have given elementary avatars of all important theorems, with appro priate suggestions for skipping. We have given complete definitions, ex planations, and proofs throughout, so that the book should be usable for individual study as well as for a course text. Prerequisites for reading the book are the following. The reader is assumed to know elementary analysis as the subject is set forth, for example, in TOM M. ApOSTOL'S Mathematical Analysis [Addison-Wesley Publ. Co., Reading, Mass., 1957], or WALTER RUDIN'S Principles of M athe nd matical Analysis [2 Ed., McGraw-Hill Book Co., New York, 1964].

The first part of a self-contained, elementary textbook, combining linear functional analysis, nonlinear functional analysis, numerical functional analysis, and their substantial applications with each other. As such, the book addresses undergraduate students and beginning graduate students of mathematics, physics, and engineering who want to learn how functional analysis elegantly solves mathematical problems which relate to our real world. Applications concern ordinary and partial differential equations, the method of finite elements, integral equations, special functions, both the Schroedinger approach and the Feynman approach to quantum physics, and quantum statistics. As a prerequisite, readers should be familiar with some basic facts of calculus. The second part has been published under the title, Applied Functional Analysis: Main Principles and Their Applications.

The book is written for students of mathematics and physics who have a basic knowledge of analysis and linear algebra. It can be used as a textbook for courses and/or seminars in functional analysis. Starting from metric spaces it proceeds quickly to the central results of the field, including the theorem of HahnBanach. The spaces (p Lp (X,(), C(X)' and Sobolov spaces are introduced. A chapter on spectral theory contains the Riesz theory of compact operators, basic facts on Banach and C*-algebras and the spectral representation for bounded normal and unbounded self-adjoint operators in Hilbert spaces. An introduction to locally convex spaces and their duality theory provides the basis for a comprehensive treatment of Fr--eacute--;chet spaces and their duals. In particular recent results on sequences spaces, linear topological invariants and short exact sequences of Fr--eacute--;chet spaces and the splitting of such sequences are presented. These results are not contained in any other book in this field.

Methods of Modern Mathematical Physics

Regularity and Approximability of Electronic Wave Functions

A First Course in Functional Analysis

Derived Functors in Functional Analysis

Lecture Notes in Real Analysis