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Differential Forms and Applications **Introduction to Matrix Analysis and Applications** Graph Theory Applications **Real Analysis: Measures, Integrals and Applications Modern Geometry with Applications** Stochastic Differential Equations **Introductory Lectures on Fluctuations of Lévy Processes with Applications Lie Sphere Geometry Geometric Methods and Applications A Course in Credibility Theory and its Applications Markov Decision Processes with Applications to Finance Discrete Stochastic Processes and Applications** *An Introduction to Riemannian Geometry* Seminar on Stochastic Analysis, Random Fields and Applications VI **Modeling, Stochastic Control, Optimization, and Applications** Stochastic Analysis and Applications to Finance **Systematic Approaches to Advanced Information Flow Analysis – and Applications to Software Security Seminar on Stochastic Analysis, Random Fields and Applications IV Linear Functional Analysis Numerical Probability** *Non-Abelian Harmonic Analysis* **Mathematical Gauge Theory Differential Geometry: Theory and Applications** The 1-2-3 of Modular Forms *Malliavin Calculus for Lévy Processes with Applications to Finance* **Fluctuations of Lévy Processes with Applications** Sparse Grids and Applications - Munich 2012 **Stochastic Differential Equations Analysis Complex Geometry** *Stochastic Differential Equations and Applications* **Mathematical Analysis I** *Numerical Range* **Sheaves in Topology** Quadrature Domains and Their Applications Financial Statistics and Mathematical Finance **A Course in Credibility Theory and its Applications** Graph Theory Applications **Stochastic Differential Equations** *The Homotopy Index and Partial Differential Equations*

I report on applications of slicing and program dependence graphs (PDGs) to software security. Moreover, I propose a framework that generalizes both data-flow analysis on control-flow graphs and slicing on PDGs. This framework can be used to systematically derive data-flow-like analyses on PDGs that go beyond slicing. I demonstrate that data-flow analysis can be systematically applied to PDGs and show the practicability of my approach. The theories of quadratic forms and their applications appear in many parts of mathematics and the sciences. All students of mathematics have the opportunity to encounter such concepts and applications in their first course in linear algebra. This subject and its extensions to infinite dimen sions comprise the theory of the numerical range W(T). There are two competing names for W(T), namely, the numerical range of T and the field of values for T. The former has been favored historically by the func tional analysis community, the latter by the matrix analysis community. It is a toss-up to decide which is preferable, and we have finally chosen the former because it is our habit, it is a more efficient expression, and because in recent conferences dedicated to W(T), even the linear algebra commu nity has adopted it. Also, one universally refers to the numerical radius, and not to the field of values radius. Originally, Toeplitz and Hausdorff called it the Wertvorrat of a bilinear form, so other good names would be value field or form values. The Russian community has referred to it as the Hausdorff domain. Murnaghan in his early paper first called it the region of the complex plane covered by those values for an n x n matrix T, then the range of values of a Hermitian matrix, then the field of values when he analyzed what he called the sought-for region. The purpose of the volume is to provide a support for a first course in Mathematics. The contents are organised to appeal especially to Engineering, Physics and Computer Science students, all areas in which mathematical tools play a crucial role. Basic notions and methods of differential and integral calculus for functions of one real variable are presented in a manner that elicits critical reading and prompts a hands-on approach to concrete applications. The layout has a specifically-designed modular nature, allowing the instructor to make flexible didactical choices when planning an introductory lecture course. The book may in fact be employed at three levels of depth. At the elementary level the student is supposed to grasp the very essential ideas and familiarise with the corresponding key techniques. Proofs to the main results befit the intermediate level, together with several remarks and complementary notes enhancing the treatise. The last, and farthest-reaching, level requires the additional study of the material contained in the appendices, which enable the strongly motivated reader to explore further into the subject. Definitions and properties are furnished with substantial examples to stimulate the learning process. Over 350 solved exercises complete the text, at least half of which guide the reader to the solution. This new edition features additional material with the aim of matching the widest range of educational choices for a first course of Mathematics. These notes are based on a postgraduate course I gave on stochastic differential equations at Edinburgh University in the spring 1982. No previous knowledge about the subject was assumed, but the presen tation is based on some background in measure theory. There are several reasons why one should learn more about stochastic differential equations: They have a wide range of applica tions outside mathematics, there are many fruitful connections to other mathematical disciplines and the subject has a rapidly develop ing life of its own as a fascinating research field with many interesting unanswered questions. Unfortunately most of the literature about stochastic differential equations seems to place so much emphasis on rigor and complete ness that is scares many nonexperts away. These notes are an attempt to approach the subject from the nonexpert point of view: Not knowing anything (except rumours, maybe) about a subject to start with, what would I like to know first of all? My answer would be: 1) In what situations does the subject arise? 2) What are its essential features? 3) What are the applications and the connections to other fields? I would not be so interested in the proof of the most general case, but rather in an easier proof of a special case, which may give just as much of the basic idea in the argument. And I would be willing to believe some basic results without proof (at first stage, anyway) in order to have time for some more basic applications. As an introduction to fundamental geometric concepts and tools needed for solving problems of a geometric nature using a computer, this book fills the gap between standard geometry books, which are primarily theoretical, and applied books on computer graphics, computer vision, or robotics that do not cover the underlying geometric concepts in detail. Gallier offers an introduction to affine, projective, computational, and Euclidean geometry, basics of differential geometry and Lie groups, and explores many of the practical applications of geometry. Some of these include computer vision, efficient communication, error correcting codes, cryptography, motion interpolation, and robot kinematics. This comprehensive text covers most of the geometric background needed for conducting research in computer graphics, geometric modeling, computer vision, and robotics and as such will be of interest to a wide audience including computer scientists, mathematicians, and engineers. Stochastic Differential Equations and Applications, Volume 1 covers the development of the basic theory of stochastic differential equation systems. This volume is divided into nine chapters. Chapters 1 to 5 deal with the basic theory of stochastic differential equations, including discussions of the Markov processes, Brownian motion, and the stochastic integral. Chapter 6 examines the connections between solutions of partial differential equations and stochastic differential equations, while Chapter 7 describes the Girsanov’s formula that is useful in the stochastic control theory. Chapters 8 and 9 evaluate the behavior of sample paths of the solution of a stochastic differential system, as time increases to infinity. This book is intended primarily for undergraduate and graduate mathematics students. This book is ideal for practicing experts in particular actuaries in the field of property-casualty insurance, life insurance, reinsurance and insurance supervision, as well as teachers and students. It provides an exploration of Credibility Theory, covering most aspects of this topic from the simplest case to the most detailed dynamic model. The book closely examines the tasks an actuary encounters daily: estimation of loss ratios, claim frequencies and claim sizes. Mathematical finance has grown into a huge area of research which requires a lot of care and a large number of sophisticated mathematical tools. Mathematically rigorous and yet accessible to advanced level practitioners and mathematicians alike, it considers various aspects of the application of statistical methods in finance and illustrates some of the many ways that statistical tools are used in financial applications. Financial Statistics and Mathematical Finance: Provides an introduction to the basics of financial statistics and mathematical finance. Explains the use and importance of statistical methods in econometrics and financial engineering. Illustrates the importance of derivatives and calculus to aid understanding in methods and results. Looks at advanced topics such as martingale theory, stochastic processes and stochastic integration. Features examples throughout to illustrate applications in mathematical and statistical finance. Is supported by an accompanying website featuring R code and data sets. Financial Statistics and Mathematical Finance introduces the financial methodology and the relevant mathematical tools in a style that is both mathematically rigorous and yet accessible to advanced level practitioners and mathematicians alike, both graduate students and researchers in statistics, finance, econometrics and business administration will benefit from this book. Unlike many other texts on differential geometry, this textbook also offers interesting applications to geometric mechanics and general relativity. The first part is a concise and self-contained introduction to the basics of manifolds, differential forms, metrics and curvature. The second part studies applications to mechanics and relativity including the proofs of the Hawking and Penrose singularity theorems. It can be independently used for one-semester courses in either of these subjects. The main ideas are illustrated and further developed by numerous examples and over 300 exercises. Detailed solutions are provided for many of these exercises, making An Introduction to Riemannian Geometry ideal for self-study. An application of differential forms for the study of some local and global aspects of the differential geometry of surfaces. Differential forms are introduced in a simple way that will make them attractive to "users" of mathematics. A brief and elementary introduction to differentiable manifolds is given so that the main theorem, namely Stokes' theorem, can be presented in its natural setting. The applications consist in developing the method of moving frames expounded by E. Cartan to study the local differential geometry of immersed surfaces in R3 as well as the intrinsic geometry of surfaces. This is then collated in the last chapter to present Chern's proof of the Gauss-Bonnet theorem for compact surfaces. Thomas Cecil is a math professor with an unrivalled grasp of Lie Sphere Geometry. Here, he provides a clear and comprehensive modern treatment of the subject, as well as its applications to the study of Euclidean submanifolds. It begins with the construction of the space of spheres, including the fundamental notions of oriented contact, parabolic pencils of spheres, and Lie sphere transformations. This new edition contains revised sections on taut submanifolds, compact proper Dupin submanifolds, reducible Dupin submanifolds, and the cyclides of Dupin. Completely new material on isoparametric hypersurfaces in spheres and Dupin hypersurfaces with three and four principal curvatures is also included. The author surveys the known results in these fields and indicates directions for further research and wider application of the methods of Lie sphere geometry. This book is ideal for practicing experts in particular actuaries in the field of property-casualty insurance, life insurance, reinsurance and insurance supervision, as well as teachers and students. It provides an exploration of Credibility Theory, covering most aspects of this topic from the simplest case to the most detailed dynamic model. The book closely examines the tasks an actuary encounters daily: estimation of loss ratios, claim frequencies and claim sizes. This book mainly discusses the representation theory of the special linear group 8L(2, 1R), and some applications of this theory. In fact the emphasis is on the applications; the working title of the book while it was being writ ten was "Some Things You Can Do with 8L(2). " Some of the applications are outside representation theory, and some are to representation theory it self. The topics outside representation theory are mostly ones of substantial classical importance (Fourier analysis, Laplace equation, Huyghens' prin ciple, Ergodic theory), while the ones inside representation theory mostly concern themes that have been central to Harish-Chandra's development of harmonic analysis on semisimple groups (his restriction theorem, regularity theorem, character formulas, and asymptotic decay of matrix coefficients and temperedness). We hope this mix of topics appeals to nonspecialists in representation theory by illustrating (without an interminable prolegom ena) how representation theory can offer new perspectives on familiar topics and by offering some insight into some important themes in representation theory itself. Especially, we hope this book popularizes Harish-Chandra's restriction formula, which, besides being basic to his work, is simply a beautiful example of Fourier analysis on Euclidean space. We also hope representation theorists will enjoy seeing examples of how their subject can be used and will be stimulated by some of the viewpoints offered on representation-theoretic issues. This text offers an introduction to the theory of graphs and its application in engineering and science. The first part covers the main graph theoretic topics: connectivity, trees, traversability, planarity, coloring, covering, matching, digraphs, networks, matrices of a graph, graph theoretic algorithms, and matroids. In the second part, these concepts are applied to problems in engineering, operations reserach, and science as well as to an interesting set of miscellaneous problems, thus iluustrating their broad applicability. Some effort has been made to present applications that use not merely the notation and terminology of graph theory, but its actual mathematical results. Some of the applications, such as in molecular evolution, facilities layout, and graffic network design, have never appeared before in book form. Written at an advanced undergraduate to beginning graduate level, the book is suitable for students of mathematics, engineering, operations resrach, computer science, and physical sciences as well as for researchers and practitioners with an interest in graph theoretic modelling. The homotopy index theory was developed by Charles Conley for two sided flows on compact spaces. The homotopy or Conley index, which provides an algebraic-topologi cal measure of an isolated invariant set, is defined to be the ho motopy type of the quotient space N /N , where is a certain 1 2 1 2 compact pair, called an index pair. Roughly speaking, N1 isolates the invariant set and N2 is the "exit ramp" of N . 1 It is shown that the index is independent of the choice of the in dex pair and is invariant under homotopic perturbations of the flow. Moreover, the homotopy index generalizes the Morse index of a nQnde generate critical point p with respect to a gradient flow on a com pact manifold. In fact if the Morse index of p is k, then the homo topy index of the invariant set {p} is Ik - the homotopy type of the pointed k-dimensional unit sphere. Constructible and perverse sheaves are the algebraic counterpart of the decomposition of a singular space into smooth manifolds. This introduction to the subject can be regarded as a textbook on modern algebraic topology, treating the cohomology of spaces with sheaf (as opposed to constant) coefficients. The author helps readers progress quickly from the basic theory to current research questions, thoroughly supported along the way by examples and exercises. The theory of Markov decision processes focuses on controlled Markov chains in discrete time. The authors establish the theory for general state and action spaces and at the same time show its application by means of numerous examples, mostly taken from the fields of finance and operations research. By using a structural approach many technicalities (concerning measure theory) are avoided. They cover problems with finite and infinite horizons, as well as partially observable Markov decision processes, piecewise deterministic Markov decision processes and stopping problems. The book presents Markov decision processes in action and includes various state-of-the-art applications with a particular view towards finance. It is useful for upper-level undergraduates, Master's students and researchers in both applied probability and finance, and provides exercises (without solutions). This unique text for beginning graduate students gives a self-contained introduction to the mathematical properties of stochastics and presents their applications to Markov processes, coding theory, population dynamics, and search engine design. The book is ideal for a newly designed course in an introduction to probability and information theory. Prerequisites include working knowledge of linear algebra, calculus, and probability theory. The first part of the text focuses on the rigorous theory of Markov processes on countable spaces (Markov chains) and provides the basis to developing solid probabilistic intuition without the need for a course in measure theory. The approach taken is gradual beginning with the case of discrete time and moving on to that of continuous time. The second part of this text is more applied; its core introduces various uses of convexity in probability and presents a nice treatment of entropy. Easily accessible Includes recent developments Assumes very little knowledge of differentiable manifolds and functional analysis Particular emphasis on topics related to mirror symmetry (SUSY, Kaehler-Einstein metrics, Tian-Todorov lemma) This textbook covers the main results and methods of real analysis in a single volume. Taking a progressive approach to equations and transformations, this book starts with the very foundations of real analysis (set theory, order, convergence, and measure theory) before presenting powerful results that can be applied to concrete problems. In addition to classical results of functional analysis, differential calculus and integration, Analysis discusses topics such as convex analysis, dissipative operators and semigroups which are often absent from classical treatises. Acknowledging that analysis has significantly contributed to the understanding and development of the present world, the book further elaborates on techniques which pervade modern civilization, including wavelets in information theory, the Radon transform in medical imaging and partial differential equations in various mechanical and physical phenomena. Advanced undergraduate and graduate students, engineers as well as practitioners wishing to familiarise themselves with concepts and applications of analysis will find this book useful. With its content split into several topics of interest, the book's style and layout make it suitable for use in several courses, while its self-contained character makes it appropriate for self-study. From the reviews: "The author, a lucid mind with a fine pedagogical instinct, has written a splendid text. He starts out by stating six problems in the introduction in which stochastic differential equations play an essential role in the solution. Then, while developing stochastic calculus, he frequently returns to these problems and variants thereof and to many other problems to show how the theory works and to motivate the next step in the theoretical development. Needless to say, he restricts himself to stochastic integration with respect to Brownian motion. He is not hesitant to give some basic results without proof in order to leave room for "some more basic applications... The book can be an ideal text for a graduate course, but it is also recommended to analysts (in particular, those working in differential equations and deterministic dynamical systems and control) who wish to learn quickly what stochastic differential equations are all about." Acta Scientiarum Mathematicarum, Tom 50, 3-4, 1986#1 "The book is well written, gives a lot of nice applications of stochastic differential equation theory, and presents theory and applications of stochastic differential equations in a way which makes the book useful for mathematical seminars at a low level. (...) The book (will) really motivate scientists from non-mathematical fields to try to understand the usefulness of stochastic differential equations in their fields." Metrica#2 Sparse grids have gained increasing interest in recent years for the numerical treatment of high-dimensional problems. Whereas classical numerical discretization schemes fail in more than three or four dimensions, sparse grids make it possible to overcome the “curse” of dimensionality to some degree, extending the number of dimensions that can be dealt with. This volume of LNCSE collects the papers from the proceedings of the second workshop on sparse grids and applications, demonstrating once again the importance of this numerical discretization scheme. The selected articles present recent advances on the numerical analysis of sparse grids as well as efficient data structures, and the range of applications extends to uncertainty quantification settings and clustering, to name but a few examples. Real Analysis: Measures, Integrals and Applications is devoted to the basics of integration theory and its related topics. The main emphasis is made on the properties of the Lebesgue integral and various applications both classical and those rarely covered in literature. This book provides a detailed introduction to Lebesgue measure and integration as well as the classical results concerning integrals of multivariable functions. It examines the concept of the Hausdorff measure, the properties of the area on smooth and Lipschitz surfaces, the divergence formula, and Laplace's method for finding the asymptotic behavior of integrals. The general theory is then applied to harmonic analysis, geometry, and topology. Preliminaries are provided on probability theory, including the study of the Rademacher functions as a sequence of independent random variables. The book contains more than 600 examples and exercises. The reader who has mastered the first third of the book will be able to study other areas of mathematics that use integration, such as probability theory, statistics, functional analysis, partial probability theory, statistics, functional analysis, partial differential equations and others. Real Analysis: Measures, Integrals and Applications is intended for advanced undergraduate and graduate students in mathematics and physics. It assumes that the reader is familiar with basic linear algebra and differential calculus of functions of several variables. This book is an introduction to Malliavin calculus as a generalization of the classical non-anticipating Ito calculus to an anticipating setting. It presents the development of the theory and its use in new fields of application. This textbook provides a self-contained introduction to numerical methods in probability with a focus on applications to finance. Topics covered include the Monte Carlo simulation (including simulation of random variables, variance reduction, quasi-Monte Carlo simulation, and more recent developments such as the multilevel paradigm), stochastic optimization and approximation, discretization schemes of stochastic differential equations, as well as optimal quantization methods. The author further presents detailed applications to numerical aspects of pricing and hedging of financial derivatives, risk measures (such as value-at-risk and conditional value-at-risk), implicitation of parameters, and calibration. Aimed at graduate students and advanced undergraduate students, this book contains useful examples and over 150 exercises, making it suitable for self-study. Quadrature domains were singled out about 30 years ago by D. Aharonov and H.S. Shapiro in connection with an extremal problem in function theory. Since then, a series of coincidental discoveries put this class of planar domains at the center of crossroads of several quite independent mathematical theories, e.g., potential theory, Riemann surfaces, inverse problems, holomorphic partial differential equations, fluid mechanics, operator theory. The volume is devoted to recent advances in the theory of quadrature domains, illustrating well the multi-facet aspects of their nature. The book contains a large collection of open problems pertaining to the general theme of quadrature domains. The first part of this text covers the main graph theoretic topics: connectivity, trees, traversability, planarity, colouring, covering, matching, digraphs, networks, matrices of a graph, graph theoretic algorithms, and matroids. These concepts are then applied in the second part to problems in engineering, operations research, and science as well as to an interesting set of miscellaneous problems, thus illustrating their broad applicability. Every effort has been made to present applications that use not merely the notation and terminology of graph theory, but also its actual mathematical results. Some of the applications, such as in molecular evolution, facilities layout, and graffic network design, have never appeared before in book form. Written at an advanced undergraduate to beginning graduate level, this book is suitable for students of mathematics, engineering, operations research, computer science, and physical sciences as well as for researchers and practitioners with an interest in graph theoretic modelling. This volume contains twenty refereed papers presented at the 4th Seminar on Stochastic Processes, Random Fields and Applications, which took place in Ascona, Switzerland, from May 2002. The seminar focused mainly on stochastic partial differential equations, stochastic models in mathematical physics, and financial engineering. The book will be a valuable resource for researchers in stochastic analysis and professionals interested in stochastic methods in finance and insurance. This volume is a collection of solicited and refereed articles from distinguished researchers across the field of stochastic analysis and its application to finance. The articles represent new directions and newest developments in this exciting and fast growing area. The covered topics range from Markov processes, backward stochastic differential equations, stochastic partial differential equations, stochastic control, potential theory, functional inequalities, optimal stopping, portfolio selection, to risk measure and risk theory. It will be a very useful book for young researchers who want to learn about the research directions in the area, as well as experienced researchers who want to know about the latest developments in the area of stochastic analysis and mathematical finance. Sample Chapter(s). Editorial Foreword (58 KB). Chapter 1: Non-Linear Evolution Equations Driven by Rough Paths (399 KB). Contents: Non-Linear Evolution Equations Driven by Rough Paths (Thomas Cass, Zhongmin Qian and Jan Tudor); Optimal Stopping Times with Different Information Levels and with Time Uncertainty (Arijit Chakrabarty and Xin Guo); Finite Horizon Optimal Investment and Consumption with CARA Utility and Proportional

Transaction Costs (Yingshan Chen, Min Dai and Kun Zhao); MUniform Integrability of Exponential Martingales and Spectral Bounds of Non-Local Feynman-Kac Semigroups (Zhen-Qing Chen); Continuous-Time Mean-Variance Portfolio Selection with Finite Transactions (Xiangyu Cui, Jianjun Gao and Duan Li); Quantifying Model Uncertainties in the Space of Probability Measures (J Duan, T Gao and G He); A PDE Approach to Multivariate Risk Theory (Robert J Elliott, Tak Kuen Siu and Hailiang Yang); Stochastic Analysis on Loop Groups (Shizan Fang); Existence and Stability of Measure Solutions for BSDE with Generators of Quadratic Growth (Alexander Fromm, Peter Imkeller and Jianing Zhang); Convex Capital Requirements for Large Portfolios (Hans FAllmer and Thomas Knispel); The Mixed Equilibrium of Insider Trading in the Market with Rational Expected Price (Fuzhou Gong and Hong Liu); Some Results on Backward Stochastic Differential Equations Driven by Fractional Brownian Motions (Yaozhong Hu, Daniel Ocone and Jian Song); Potential Theory of Subordinate Brownian Motions Revisited (Panki Kim, Renming Song and Zoran Vondraiek); Research on Social Causes of the Financial Crisis (Steven Kou); Wick Formulas and Inequalities for the Quaternion Gaussian and -Permanental Variables (Wenbo V Li and Ang Wei); Further Study on Web Markov Skeleton Processes (Yuting Liu, Zhi-Ming Ma and Chuan Zhou); MLE of Parameters in the Drifted Brownian Motion and Its Error (Lemee Nakamura and Weian Zheng); Optimal Partial Information Control of SPDEs with Delay and Time-Advanced Backward SPDEs (Bernt yksendal, Agn s Sulem and Tusheng Zhang); Simulation of Diversified Portfolios in Continuous Financial Markets (Eckhard Platen and Renata Rendek); Coupling and Applications (Feng-Yu Wang); SDEs and a Generalised Burgers Equation (Jiang-Lun Wu and Wei Yang); Mean-Variance Hedging in the Discontinuous Case (Jianming Xia). Readership: Graduates and researchers in stochatic analysis and mathematical finance. This book gives an introduction to Linear Functional Analysis, which is a synthesis of algebra, topology, and analysis. In addition to the basic theory it explains operator theory, distributions, Sobolev spaces, and many other things. The text is self-contained and includes all proofs, as well as many exercises, most of them with solutions. Moreover, there are a number of appendices, for example on Lebesgue integration theory. A complete introduction to the subject, Linear Functional Analysis will be particularly useful to readers who want to quickly get to the key statements and who are interested in applications to differential equations. This book grew out of three series of lectures given at the summer school on "Modular Forms and their Applications" at the Sophus Lie Conference Center in Nordfjordeid in June 2004. The first series treats the classical one-variable theory of elliptic modular forms. The second series presents the theory of Hilbert modular forms in two variables and Hilbert modular surfaces. The third series gives an introduction to Siegel modular forms and discusses a conjecture by Harder. It also contains Harder's original manuscript with the conjecture.

Each part treats a number of beautiful applications. Matrices can be studied in different ways. They are a linear algebraic structure and have a topological/analytical aspect (for example, the normed space of matrices) and they also carry an order structure that is induced by positive semidefinite matrices. The interplay of these closely related structures is an essential feature of matrix analysis. This book explains these aspects of matrix analysis from a functional analysis point of view. After an introduction to matrices and functional analysis, it covers more advanced topics such as matrix monotone functions, matrix means, majorization and entropies. Several applications to quantum information are also included. Introduction to Matrix Analysis and Applications is appropriate for an advanced graduate course on matrix analysis, particularly aimed at studying quantum information. It can also be used as a reference for researchers in quantum information, statistics, engineering and economics. This textbook forms the basis of a graduate course on the theory and applications of Lévy processes, from the perspective of their path fluctuations. The book aims to be mathematically rigorous while still providing an intuitive feel for underlying principles. The results and applications often focus on the case of Lévy processes with jumps in only one direction, for which recent theoretical advances have yielded a higher degree of mathematical transparency and explicitness. This volume collects papers, based on invited talks given at the IMA workshop in Modeling, Stochastic Control, Optimization, and Related Applications, held at the Institute for Mathematics and Its Applications, University of Minnesota, during May and June, 2018. There were four week-long workshops during the conference. They are (1) stochastic control, computation methods, and applications, (2) queueing theory and networked systems, (3) ecological and biological applications, and (4) finance and economics applications. For broader impacts, researchers from different fields covering both theoretically oriented and application intensive areas were invited to participate in the conference. It brought together researchers from multi-disciplinary communities in applied mathematics, applied probability, engineering, biology, ecology, and networked science, to review, and substantially update most recent progress. As an archive, this volume presents some of the highlights of the workshops, and collect papers covering a broad range of topics. This introduction to modern geometry differs from other books in the field due to its emphasis on applications and its discussion of special relativity as a major example of a non-Euclidean geometry. Additionally, it covers the two important areas of non-Euclidean geometry, spherical geometry and projective geometry, as well as emphasising transformations, and conics and planetary orbits. Much emphasis is placed on applications throughout the book, which motivate the topics, and many additional applications are given in the exercises. It makes an excellent introduction for those who need to know how geometry is used in addition to its formal theory. The Standard Model is the foundation of modern particle and high energy physics. This book explains the mathematical background behind the Standard Model, translating ideas from physics into a mathematical language and vice versa. The first part of the book covers the mathematical theory of Lie groups and Lie algebras, fibre bundles, connections, curvature and spinors. The second part then gives a detailed exposition of how these concepts are applied in physics, concerning topics such as the Lagrangians of gauge and matter fields, spontaneous symmetry breaking, the Higgs boson and mass generation of gauge bosons and fermions. The book also contains a chapter on advanced and modern topics in particle physics, such as neutrino masses, CP violation and Grand Unification. This carefully written textbook is aimed at graduate students of mathematics and physics. It contains numerous examples and more than 150 exercises, making it suitable for self-study and use alongside lecture courses. Only a basic knowledge of differentiable manifolds and special relativity is required, summarized in the appendix. This volume contains refereed research or review papers presented at the 6th Seminar on Stochastic Processes, Random Fields and Applications, which took place at the Centro Stefano Franscini (Monte Verità) in Ascona, Switzerland, in May 2008. The seminar focused mainly on stochastic partial differential equations, especially large deviations and control problems, on infinite dimensional analysis, particle systems and financial engineering, especially energy markets and climate models. The book will be a valuable resource for researchers in stochastic analysis and professionals interested in stochastic methods in finance. Lévy processes are the natural continuous-time analogue of random walks and form a rich class of stochastic processes around which a robust mathematical theory exists. Their application appears in the theory of many areas of classical and modern stochastic processes including storage models, renewal processes, insurance risk models, optimal stopping problems, mathematical finance, continuous-state branching processes and positive self-similar Markov processes. This textbook is based on a series of graduate courses concerning the theory and application of Lévy processes from the perspective of their path fluctuations. Central to the presentation is the decomposition of paths in terms of excursions from the running maximum as well as an understanding of short- and long-term behaviour. The book aims to be mathematically rigorous while still providing an intuitive feel for underlying principles. The results and applications often focus on the case of Lévy processes with jumps in only one direction, for which recent theoretical advances have yielded a higher degree of mathematical tractability. The second edition additionally addresses recent developments in the potential analysis of subordinators, Wiener-Hopf theory, the theory of scale functions and their application to ruin theory, as well as including an extensive overview of the classical and modern theory of positive self-similar Markov processes. Each chapter has a comprehensive set of exercises.