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A unified account of the major new developments inspired by Maurey's application of Banach space ultraproducts to the fixed point theory for non-expansive mappings is given in this text. The first third of the book is devoted to laying a careful foundation for the actual fixed point theoretic results which follow. Set theoretic and Banach space ultraproducts constructions are studied in detail in the second part of the book, while the remainder of the book gives an introduction to the classical fixed point theory in addition to a discussion of normal structure. This is the first book which studies classical fixed point theory for non-expansive maps in the view of non-standard methods. This monograph collects cutting-edge results and techniques for solving nonlinear partial differential equations using critical points. Including many of the author ’ s own contributions, a range of proofs are conveniently collected here, Because the material is approached with rigor, this book will serve as an invaluable resource for exploring recent developments in this active area of research, as well as the numerous ways in which critical point theory can be applied. Different methods for finding critical points are presented in the first six chapters. The specific situations in which these methods are applicable is explained in detail. Focus then shifts toward the book ’ s main subject: applications to problems in mathematics and physics. These include topics such as Schr ö dinger equations, Hamiltonian systems, elliptic systems, nonlinear wave equations, nonlinear optics, semilinear PDEs, boundary value problems, and equations with multiple solutions. Readers will find this collection of applications convenient and thorough, with detailed proofs appearing throughout. Critical Point Theory will be ideal for graduate students and researchers interested in solving differential equations, and for those studying variational methods. An understanding of fundamental mathematical analysis is assumed. In particular, the basic properties of Hilbert and Banach spaces are used. Fixed Point Theory & Applications Volume II Fixed point theory touches on many areas of mathematics, such as general topology, algebraic topology, nonlinear functional analysis, and ordinary and partial differential equations and serves as a useful tool in applied mathematics. This book represents the proceedings of an informal three-day seminar held during the International Congress of Mathematicians in Berkeley in 1986. Bringing together topologists and analysts concerned with the study of fixed points of continuous functions, the seminar provided a forum for presentation of recent developments in several different areas. The topics covered include both topological fixed point theory from both the algebraic and geometric viewpoints, the fixed point theory of nonlinear operators on normed linear spaces and its applications, and the study of solutions of ordinary and partial differential equations by fixed point theory methods. Because the papers range from broad expositions to specialized research papers, the book provides readers with a good overview of the subject as well as a more detailed look at some specialized recent advances. My book "Asymptotic Expansions for Ordinary Differential Equations" published in 1965 is out of print. In the almost 20 years since then, the subject has grown so much in breadth and in depth that an account of the present state of knowledge of all the topics discussed there could not be fitted into one volume without resorting to an excessively terse style of writing. Instead of undertaking such a task, I have concentrated, in this exposi tion, on the aspects of the asymptotic theory with which I have been particularly concerned during those 20 years, which is the nature and structure of turning points. As in Chapter VIII of my previous book, only linear analytic differential equations are considered, but the inclusion of important new ideas and results, as well as the development of the neces sary background material have made this an exposition of book length. The formal theory of linear analytic differential equations without a parameter near singularities with respect to the independent variable has, in recent years, been greatly deepened by bringing to it methods of modern algebra and topology. It is very probable that many of these ideas could also be applied to the problems concerning singularities with respect to a parameter, and I hope that this will be done in the near future. It is less likely, however, that the analytic, as opposed to the formal, aspects of turning point theory will greatly benefit from such an algebraization. Starting with the simplest examples, this book gives an easy introduction to the subject, then explains several very recent developments. It makes available in the English language the covering space approach to Nielsen fixed point theory. As far as research value is concerned, the Nielsen theory of periodic points is published here for the first time, and an exposition and improvement of the latest progress in the Nielsen theory of fiber maps is provided. Presents up-to-date Banach space results. * Features an extensive bibliography for outside reading. * Provides detailed exercises that elucidate more introductorymaterial. The aim of this volume is to make available to a large audience recent material in nonlinear functional analysis that has not been covered in book format before. Here, several topics of current and growing interest are systematically presented, such as fixed point theory, best approximation, the KKM-map principle, and results related to optimization theory, variational inequalities and complementarity problems. Illustrations of suitable applications are given, the links between results in various fields of research are highlighted, and an up-to-date bibliography is included to assist readers in further studies. Audience: This book will be of interest to graduate students, researchers and applied mathematicians working in nonlinear functional analysis, operator theory, approximations and expansions, convex sets and related geometric topics and game theory. There are refinements of the Lefschetz number and the fixed point index that give a converse to the Lefschetz fixed point theorem. An important part of this theorem is the identification of these different invariants. This book collects papers on major topics in fixed point theory and its applications. Each chapter is accompanied by basic notions, mathematical preliminaries and proofs of the main results. The book discusses common fixed point theory, convergence theorems, split variational inclusion problems and fixed point problems for asymptotically nonexpansive semigroups; fixed point property and almost fixed point property in digital spaces, nonexpansive semigroups over CAT(κ) spaces, measures of noncompactness, integral equations, the study of fixed points that are zeros of a given function, best proximity point theory, monotone mappings in modular function spaces, fuzzy contractive mappings, ordered hyperbolic metric spaces, generalized contractions in b-metric spaces, multi-tupled fixed points, functional equations in dynamic programming and Picard operators. This book addresses the mathematical community working with methods and tools of nonlinear analysis. It also serves as a reference, source for examples and new approaches associated with fixed point theory and its applications for a wide audience including graduate students and researchers. Written by a team of leading experts in the field, this volume presents a self-contained account of the theory, techniques and results in metric type spaces (in particular in G-metric spaces); that is, the text approaches this important area of fixed point analysis beginning from the basic ideas of metric space topology. The text is structured so that it leads the reader from preliminaries and historical notes on metric spaces (in particular G-metric spaces) and on mappings, to Banach type contraction theorems in metric type spaces, fixed point theory in partially ordered G-metric spaces, fixed point theory for expansive mappings in metric type spaces, generalizations, present results and techniques in a very general abstract setting and framework. Fixed point theory is one of the major research areas in nonlinear analysis. This is partly due to the fact that in many real world problems fixed point theory is the basic mathematical tool used to establish the existence of solutions to problems which arise naturally in applications. As a result, fixed point theory is an important area of study in pure and applied mathematics and it is a flourishing area of research. Metric Fixed Point Theory has proved a flourishing area of research for many mathematicians. This book aims to offer the mathematical community an accessible, self-contained account which can be used as an introduction to the subject and its development. It will be understandable to a wide audience, including non-specialists, and provide a source of examples, references and new approaches for those currently working in the subject. This book addresses fixed point theory, a fascinating and far-reaching field with applications in several areas of mathematics. The content is divided into two main parts. The first, which is more theoretical, develops the main abstract theorems on the existence and uniqueness of fixed points of maps. In turn, the second part focuses on applications, covering a large variety of significant results ranging from ordinary differential equations in Banach spaces, to partial differential equations, operator theory, functional analysis, measure theory, and game theory. A final section containing 50 problems, many of which include helpful hints, rounds out the coverage. Intended for Master's and PhD students in Mathematics or, more generally, mathematically oriented subjects, the book is designed to be largely self-contained, although some mathematical background is needed: readers should be familiar with measure theory, Banach and Hilbert spaces, locally convex topological vector spaces and, in general, with linear functional analysis. This is the first general introduction to stability of ordinary and functional differential equations by means of fixed point techniques. Suitable for advanced undergraduates and graduate students, it contains an extensive collection of new and classical examples, all worked in detail and presented in an elementary manner. 2006 edition. Fixed point theory touches on many areas of mathematics, such as general topology, algebraic topology, nonlinear functional analysis, and ordinary and partial differential equations and serves as a useful tool in applied mathematics. This book represents the proceedings of an informal three-day seminar held during the International Congress of Mathematicians in Berkeley in 1986. Bringing together topologists and analysts concerned with the study of fixed points of continuous functions, the seminar provided a forum for presentation of recent developments in several different areas. The topics covered include both topological fixed point theory from both the algebraic and geometric viewpoints, the fixed point theory of nonlinear operators on normed linear spaces and its applications, and the study of solutions of ordinary and partial differential equations by fixed point theory methods.Because the papers range from broad expositions to specialized research papers, the book provides readers with a good overview of the subject as well as a more detailed look at some specialized recent advances. This monograph provides a unified and comprehensive treatment of an order-theoretic fixed point theory in partially ordered sets and its various useful interactions with topological structures. The material progresses systematically, by presenting the preliminaries before moving to more advanced topics. In the treatment of the applications a wide range of mathematical theories and methods from nonlinear analysis and integration theory are applied; an outline of which has been given an appendix chapter to make the book self-contained. Graduate students and researchers in nonlinear analysis, pure and applied mathematics, game theory and mathematical economics will find this book useful. Metric fixed point theory encompasses the branch of fixed point theory which metric conditions on the underlying space and/or on the mappings play a fundamental role. In some sense the theory is a far-reaching outgrowth of Banach's contraction mapping principle. A natural extension of the study of contractions is the limiting case when the Lipschitz constant is allowed to equal one. Such mappings are called nonexpansive. Nonexpansive mappings arise in a variety of natural ways, for example in the study of holomorphic mappings and hyperconvex metric spaces. Because most of the spaces studied in analysis share many algebraic and topological properties as well as metric properties, there is no clear line separating metric fixed point theory from the topological or set-theoretic branch of the theory. Also, because of its metric underpinnings, metric fixed point theory has provided the motivation for the study of many geometric properties of Banach spaces. The contents of this Handbook reflect all of these facts. The purpose of the Handbook is to provide a primary resource for anyone interested in fixed point theory with a metric flavor. The goal is to provide information for those wishing to find results that might apply to their own work and for those wishing to obtain a deeper understanding of the theory. The book should be of interest to a wide range of researchers in mathematical analysis as well as to those whose primary interest is the study of fixed point theory and the underlying spaces. The level of exposition is directed to a wide audience, including students and established researchers. This book presents some of the latest research in critical point theory, describing methods and presenting the newest applications. Coverage includes extrema, even valued functionals, weak and double linking, sign changing solutions, Morse inequalities, and cohomology groups. Applications described include Hamiltonian systems, Schr ö dinger equations and systems, jumping nonlinearities, elliptic equations and systems, superlinear problems and beam equations. The purpose of this contributed volume is to provide a primary resource for anyone interested in fixed point theory with a metric flavor. The book presents information for those wishing to find results that might apply to their own work and for those wishing to obtain a deeper understanding of the theory. The book should be of interest to a wide range of researchers in mathematical analysis as well as to those whose primary interest is the study of fixed point theory and the underlying spaces. The level of exposition is directed to a wide audience, including students and established researchers. Key topics covered include Banach contraction theorem, hyperconvex metric spaces, modular function spaces, fixed point theory in ordered sets, topological fixed point theory for set-valued maps, coincidence theorems, Lefschetz and Nielsen theories, systems of nonlinear inequalities, iterative methods for fixed point problems, and the Ekeland ' s variational principle. Fixed point theory in probabilistic metric spaces can be considered as a part of Probabilistic Analysis, which is a very dynamic area of mathematical research. A primary aim of this monograph is to stimulate interest among scientists and students in this fascinating field. The text is self-contained for a reader with a modest knowledge of the metric fixed point theory. Several themes run through this book. The first is the theory of triangular norms (t-norms), which is closely related to fixed point theory in probabilistic metric spaces. Its recent development has had a strong influence upon the fixed point theory in probabilistic metric spaces. In Chapter 1 some basic properties of t-norms are presented and several special classes of t-norms are investigated. Chapter 2 is an overview of some basic definitions and examples from the theory of probabilistic metric spaces. Chapters 3, 4, and 5 deal with some single-valued and multi-valued probabilistic versions of the Banach contraction principle. In Chapter 6, some basic results in locally convex topological vector spaces are used and applied to fixed point theory in vector spaces. Audience: The book will be of value to graduate students, researchers, and applied mathematicians working in nonlinear analysis and probabilistic metric spaces. Decomposable sets since T. R. Rockafellar in 1968 are one of basic notions in nonlinear analysis, especially in the theory of multifunctions. A subset K of measurable functions is called decomposable if (Q) for all and measurable A. This book attempts to show the present stage of "decomposable analysis" from the point of view of fixed point theory. The book is split into three parts, beginning with the background of functional analysis, proceeding to the theory of multifunctions and lastly, the decomposability property. Mathematicians and students working in functional, convex and nonlinear analysis, differential inclusions and optimal control should find this book of interest. A good background in fixed point theory is assumed as is a background in topology. This book develops the central aspect of fixed point theory – the topological fixed point index – to maximal generality, emphasizing correspondences and other aspects of the theory that are of special interest to economics. Numerous topological consequences are presented, along with important implications for dynamical systems. The book assumes the reader has no mathematical knowledge beyond that which is familiar to all theoretical economists. In addition to making the material available to a broad audience, avoiding algebraic topology results in more geometric and intuitive proofs. Graduate students and researchers in economics, and related fields in mathematics and computer science, will benefit from this book, both as a useful reference and as a well-written rigorous exposition of foundational mathematics. Numerous problems sketch key results from a wide variety of topics in theoretical economics, making the book an outstanding text for advanced graduate courses in economics and related disciplines. This book provides a clear exposition of the flourishing field of fixed point theory. Starting from the basics of Banach's contraction theorem, most of the main results and techniques are developed: fixed point results are established for several classes of maps and the three main approaches to establishing continuation principles are presented. The theory is applied to many areas of interest in analysis. Topological considerations play a crucial role, including a final chapter on the relationship with degree theory. Researchers and graduate students in applicable analysis will find this to be a useful survey of the fundamental principles of the subject. The very extensive bibliography and close to 100 exercises mean that it can be used both as a text and as a comprehensive reference work, currently the only one of its type. This book collects chapters on fixed-point theory and fractional calculus and their applications in science and engineering. It discusses state-of-the-art developments in these two areas through original new contributions from scientists across the world. It contains several useful tools and techniques to develop their skills and expertise in fixed-point theory and fractional calculus. New research directions are also indicated in chapters. This book is meant for graduate students and researchers willing to expand their knowledge in these areas. The minimum prerequisite for readers is the graduate-level knowledge of analysis, topology and functional analysis. It is an indisputable argument that the formulation of metrics (by Fr é chet in the early 1900s) opened a new subject in mathematics called non-linear analysis after the appearance of Banach ’ s fixed point theorem. Because the underlying space of this theorem is a metric space, the theory that developed following its publication is known as metric fixed point theory. It is well known that metric fixed point theory provides essential tools for solving problems arising in various branches of mathematics and other sciences such as split feasibility problems, variational inequality problems, non-linear optimization problems, equilibrium problems, selection and matching problems, and problems of proving the existence of solutions of integral and differential equations are closely related to fixed point theory. For this reason, many people over the past seventy years have tried to generalize the definition of metric space and corresponding fixed point theory. This trend still continues. A few questions lying at the heart of the theory remain open and there are many unanswered questions regarding the limits to which the theory may be extended. Metric Structures and Fixed Point Theory provides an extensive understanding and the latest updates on the subject. The book not only shows diversified aspects of popular generalizations of metric spaces such as symmetric, b-metric, w-distance, G-metric, modular metric, probabilistic metric, fuzzy metric, graphical metric and corresponding fixed point theory but also motivates work on existing open problems on the subject. Each of the nine chapters—contributed by various authors—contains an Introduction section which summarizes the material needed to read the chapter independently of the others and contains the necessary background, several examples, and comprehensive literature to comprehend the concepts presented therein. This is helpful for those who want to pursue their research career in metric fixed point theory and its related areas. Features Explores the latest research and developments in fixed point theory on the most popular generalizations of metric spaces Description of various generalizations of metric spaces Very new topics on fixed point theory in graphical and modular metric spaces Enriched with examples and open problems This book serves as a reference for scientific investigators who need to analyze a simple and direct presentation of the fundamentals of the theory of metric fixed points. It may also be used as a text book for postgraduate and research students who are trying to derive future research scope in this area. This volume presents a broad introduction to the topological fixed point theory of multivalued (set-valued) mappings, treating both classical concepts as well as modern techniques. A variety of up-to-date results is described within a unified framework. This book explores fixed point theorems and its uses in economics, co-operative and noncooperative games. "Fixed-point theory initially emerged in the article demonstrating existence of solutions of differential equations, which appeared in the second quarter of the 18th century (Joseph Liouville, 1837). Later on, this technique was improved as a method of successive approximations (Charles Emile Picard, 1890) which was extracted and abstracted as a fixed-point theorem in the framework of complete normed space (Stefan Banach, 1922). It ensures presence as well as uniqueness of a fixed point, gives an approximate technique to really locate the fixed point and the a priori and a posteriori estimates for the rate of convergence. It is an essential device in the theory of metric spaces. Subsequently, it is stated that fixed-point theory is initiated by Stefan Banach. Fixed-point theorems give adequate conditions under which there exists a fixed point for a given function and enable us to ensure the existence of a solution of the original problem. In an extensive variety of scientific issues, beginning from different branches of mathematics, the existence of a solution is comparable to the existence of a fixed point for a suitable mapping. The book "Fixed Point Theory & its Applications to Real World Problems" is an endeavour to present results in fixed point theory which are extensions, improvements and generalizations of classical and recent results in this area and touches on distinct research directions within the metric fixed-point theory. It provides new openings for further exploration and makes for an easily accessible source of knowledge. This book is apposite for young researchers who want to pursue their research in fixed-point theory and is the latest in the field, giving new techniques for the existence of a superior fixed point, a fixed point, a near fixed point, a fixed circle, a near fixed interval circle, a fixed disc, a near fixed interval disc, a coincidence point, a common fixed point, a coupled common fixed point, amiable fixed sets, strong coupled fixed points and so on, utilizing minimal conditions. It offers novel applications besides traditional applications which are applicable to real world problems. The book is self-contained and unified which will serve as a reference book to researchers who are in search of novel ideas. It will be a valued addition to the library"-- As is well known, The Great Divide (a.k.a. The Continental Divide) is formed by the Rocky Mountains stretching from north to south across North America. It creates a virtual "stone wall" so high that wind, rain, snow, etc. cannot cross it. This keeps the weather distinct on both sides. Since railroad trains cannot climb steep grades and tunnels through these mountains are almost formidable, the Canadian Pacific Railroad searched for a mountain pass providing the lowest grade for its tracks. Employees discovered a suitable mountain pass, called the Kicking Horse Pass, el. 5404 ft., near Banff, Alberta. (One can speculate as to the reason for the name.) This pass is also used by the Trans-Canada Highway. At the highest point of the pass the railroad tracks are horizontal with mountains rising on both sides. A mountain stream divides into two branches, one flowing into the Atlantic Ocean and the other into the Pacific. One can literally stand (as the author did) with one foot in the Atlantic Ocean and the other in the Pacific. The author has observed many mountain passes in the Rocky Mountains and Alps. What connections do mountain passes have with nonlinear partial dif ferential equations? To find out, read on ... In recent years, the fixed point theory of Lipschitzian-type mappings has rapidly grown into an important field of study in both pure and applied mathematics. It has become one of the most essential tools in nonlinear functional analysis. This self-contained book provides the first systematic presentation of Lipschitzian-type mappings in metric and Banach spaces. The first chapter covers some basic properties of metric and Banach spaces. Geometric considerations of underlying spaces play a prominent role in developing and understanding the theory. The next two chapters provide background in terms of convexity, smoothness and geometric coefficients of Banach spaces including duality mappings and metric projection mappings. This is followed by results on existence of fixed points, approximation of fixed points by iterative methods and strong convergence theorems. The final chapter explores several applicable problems arising in related fields. This book can be used as a textbook and as a reference for graduate students, researchers and applied mathematicians working in nonlinear functional analysis, operator theory, approximations by iteration theory, convexity and related geometric topics, and best approximation theory. This is a monograph on fixed point theory, covering the purely metric aspects of the theory – particularly results that do not depend on any algebraic structure of the underlying space. Traditionally, a large body of metric fixed point theory has been couched in a functional analytic framework. This aspect of the theory has been written about extensively. There are four classical fixed point theorems against which metric extensions are usually checked. These are, respectively, the Banach contraction mapping principal, Nadler ' s well known set-valued extension of that theorem, the extension of Banach ' s theorem to nonexpansive mappings, and Caristi ' s theorem. These comparisons form a significant component of this book. This book is divided into three parts. Part I contains some aspects of the purely metric theory, especially Caristi ' s theorem and a few of its many extensions. There is also a discussion of nonexpansive mappings, viewed in the context of logical foundations. Part I also contains certain results in hyperconvex metric spaces and ultrametric spaces. Part II treats fixed point theory in classes of spaces which, in addition to having a metric structure, also have geometric structure. These specifically include the geodesic spaces, length spaces and CAT(0) spaces. Part III focuses on distance spaces that are not necessarily metric. These include certain distance spaces which lie strictly between the class of semimetric spaces and the class of metric spaces, in that they satisfy relaxed versions of the triangle inequality, as well as other spaces whose distance properties do not fully satisfy the metric axioms. Fixed Point Theory & Applications Fixed Point Theory, Variational Analysis, and Optimization not only covers three vital branches of nonlinear analysis-fixed point theory, variational inequalities, and vector optimization-but also explains the connections between them, enabling the study of a general form of variational inequality problems related to the optimality conditions invol What is clear and easy to grasp attracts us; complications deter David Hilbert The material presented in this volume is based on discussions conducted in peri odically held seminars by the Nonlinear Functional Analysis research group of the University of

Seville. This book is mainly addressed to those working or aspiring to work in the field of measures of noncompactness and metric fixed point theory. Special em phasis is made on the results in metric fixed point theory which were derived from geometric coefficients defined by means of measures of noncompactness and on the relationships between nonlinear operators which are contractive for different measures. Several topics in these notes can be found either in texts on measures of noncompactness (see [AKPRSj, [BG]) or in books on metric fixed point theory (see [GK1], [Sm], [Z]). Many other topics have come from papers where the authors of this volume have published the results of their research over the last ten years. However, as in any work of this type, an effort has been made to revise many proofs and to place many others in a correct setting. Our research was made possible by partial support of the D.G.I.C.y'T. and the Junta de Andalucia. FACHGEB The last decade has seen a tremendous development in critical point theory in infinite dimensional spaces and its application to nonlinear boundary value problems. In particular, striking results were obtained in the classical problem of periodic solutions of Hamiltonian systems. This book provides a systematic presentation of the most basic tools of critical point theory: minimization, convex functions and Fenchel transform, dual least action principle, Ekeland variational principle, minimax methods, Lusternik- Schirelmann theory for Z2 and S1 symmetries, Morse theory for possibly degenerate critical points and non-degenerate critical manifolds. Each technique is illustrated by applications to the discussion of the existence, multiplicity, and bifurcation of the periodic solutions of Hamiltonian systems. Among the treated questions are the periodic solutions with fixed period or fixed energy of autonomous systems, the existence of subharmonics in the non-autonomous case, the asymptotically linear Hamiltonian systems, free and forced superlinear problems. Application of those results to the equations of mechanical pendulum, to Josephson systems of solid state physics and to questions from celestial mechanics are given. The aim of the book is to introduce a reader familiar to more classical techniques of ordinary differential equations to the powerful approach of modern critical point theory. The style of the exposition has been adapted to this goal. The new topological tools are introduced in a progressive but detailed way and immediately applied to differential equation problems. The abstract tools can also be applied to partial differential equations and the reader will also find the basic references in this direction in the bibliography of more than 500 items which concludes the book. ERSCHEIN Fixed Point Theory and Graph Theory provides an intersection between the theories of fixed point theorems that give the conditions under which maps (single or multivalued) have solutions and graph theory which uses mathematical structures to illustrate the relationship between ordered pairs of objects in terms of their vertices and directed edges. This edited reference work is perhaps the first to provide a link between the two theories, describing not only their foundational aspects, but also the most recent advances and the fascinating intersection of the domains. The authors provide solution methods for fixed points in different settings, with two chapters devoted to the solutions method for critically important non-linear problems in engineering, namely, variational inequalities, fixed point, split feasibility, and hierarchical variational inequality problems. The last two chapters are devoted to integrating fixed point theory in spaces with the graph and the use of retractions in the fixed point theory for ordered sets. Introduces both metric fixed point and graph theory in terms of their disparate foundations and common application environments Provides a unique integration of otherwise disparate domains that aids both students seeking to understand either area and researchers interested in establishing an integrated research approach Emphasizes solution methods for fixed points in non-linear problems such as variational inequalities, split feasibility, and hierarchical variational inequality problems that is particularly appropriate for engineering and core science applications The theory of Fixed Points is one of the most powerful tools of modern mathematics. This book contains a clear, detailed and well-organized presentation of the major results, together with an entertaining set of historical notes and an extensive bibliography describing further developments and applications. From the reviews: "I recommend this excellent volume on fixed point theory to anyone interested in this core subject of nonlinear analysis." --MATHEMATICAL REVIEWS