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# Combinatorial Mathematics The Carus Mathematical Monographs 14

**This volume contains the invited papers from the 1983 British Combinatorial Conference. Several distinguished mathematicians were invited to give a lecture and write a paper for the conference volume. The papers cover a broad range of combinatorial topics, including enumeration, finite geometries, graph theory and permanents. This is the first book devoted to the exposition of**

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**combinatorial matrix theory. It can be used as a graduate course text, but is complete enough for a standard reference work on the basic theory.**

**This book is the second part of the new edition of Advanced Modern Algebra (the first part published as Graduate Studies in Mathematics, Volume 165).**

**Compared to the previous edition, the material has been significantly reorganized and many sections have been rewritten. The book presents many topics mentioned in the first part in greater depth and in more detail. The five chapters of the book are devoted to group theory, representation theory, homological algebra, categories, and commutative algebra, respectively. The book can be used**

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**as a text for a second abstract algebra graduate course, as a source of additional material to a first abstract algebra graduate course, or for self-study.**

**Now with solutions to selected problems, Applied Combinatorics, Second Edition presents the tools of combinatorics from an applied point of view. This bestselling textbook offers numerous references to the literature of combinatorics and its applications that enable readers to delve more deeply into the topics. After introducing fundamental counting**

**Applied Combinatorics**

**Algebraic and Geometric Combinatorics**

**Theory and Practice of Combinatorics**

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**The William Lowell Putnam Mathematical Competition  
2001–2016: Problems, Solutions, and Commentary  
Proceedings of the Organic Mathematics Workshop,  
December 12-14, 1995, Simon Fraser University, Burnaby,  
British Columbia**

On March 28~31, 1994 (Farvardin 8~11, 1373  
by Iranian calendar), the Twenty fifth  
Annual Iranian Mathematics Conference  
(AIMC25) was held at Sharif University of  
Technology in Tehran, Islamic Republic of  
Iran. Its sponsors included the Iranian  
Mathematical Society, and the Department  
of Mathematical Sciences at Sharif

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University of Technology. Among the keynote speakers were Professor Dr. Andreas Dress and Professor Richard K. Guy. Their plenary lectures on combinatorial themes were complemented by invited and contributed lectures in a Combinatorics Session. This book is a collection of refereed papers, submitted primarily by the participants after the conference. The topics covered are diverse, spanning a wide range of combinatorics and allied areas in discrete mathematics. Perhaps the strength

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and variety of the papers here serve as the best indications that combinatorics is advancing quickly, and that the Iranian mathematics community contains very active contributors. We hope that you find the papers mathematically stimulating, and look forward to a long and productive growth of combinatorial mathematics in Iran.

Over the past two decades, research in the theory of Latin Squares has been growing at a fast pace, and new significant developments have taken place. This book

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offers a unique approach to various areas of discrete mathematics through the use of Latin Squares.

This book, dedicated to the memory of Gian-Carlo Rota, is the result of a collaborative effort by his friends, students and admirers. Rota was one of the great thinkers of our times, innovator in both mathematics and phenomenology. I feel moved, yet touched by a sense of sadness, in presenting this volume of work, despite the fear that I may be unworthy of the task that befalls me. Rota, both the

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scientist and the man, was marked by a generosity that knew no bounds. His ideas opened wide the horizons of fields of research, permitting an astonishing number of students from all over the globe to become enthusiastically involved. The contagious energy with which he demonstrated his tremendous mental capacity always proved fresh and inspiring. Beyond his renown as gifted scientist, what was particularly striking in Gian-Carlo Rota was his ability to appreciate the diverse intellectual



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capacities of those before him and to adapt his communications accordingly. This human sense, complemented by his acute appreciation of the importance of the individual, acted as a catalyst in bringing forth the very best in each one of his students. Whosoever was fortunate enough to enjoy Gian-Carlo Rota's longstanding friendship was most enriched by the experience, both mathematically and philosophically, and had occasion to appreciate son cote de bon vivant. The book opens with a heartfelt piece by Henry

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Crapo in which he meticulously pieces together what Gian-Carlo Rota's untimely demise has bequeathed to science.

**Algebraic and Geometric Combinatorics**  
**Proceedings of the NATO Advanced Study**  
**Institute held at Nijenrode Castle,**  
**Breukelen, The Netherlands 8-20 July 1974**  
**Introductory Discrete Mathematics**  
**Discrete Mathematics Using Latin Squares**  
**Surveys in Combinatorics**  
**Room Squares, Sum-Free Sets, Hadamard**  
**Matrices**

The William Lowell Putnam Mathematics

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Competition is the most prestigious undergraduate mathematics problem-solving contest in North America, with thousands of students taking part every year. This volume presents the contest problems for the years 2001–2016. The heart of the book is the solutions; these include multiple approaches, drawn from many sources, plus insights into navigating from the problem statement to a solution. There is also a section of hints, to encourage readers to engage deeply with the problems before consulting the solutions. The

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authors have a distinguished history of engagement with, and preparation of students for, the Putnam and other mathematical competitions. Collectively they have been named Putnam Fellow (top five finisher) ten times. Kiran Kedlaya also maintains the online Putnam Archive.

Although they play a fundamental role in nearly all branches of mathematics, inequalities are usually obtained by ad hoc methods rather than as consequences of some underlying "theory of inequalities." For

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certain kinds of inequalities, the notion of majorization leads to such a theory that is sometimes extremely useful and powerful for deriving inequalities. Moreover, the derivation of an inequality by methods of majorization is often very helpful both for providing a deeper understanding and for suggesting natural generalizations. Anyone wishing to employ majorization as a tool in applications can make use of the theorems; for the most part, their statements are easily understood. It is now generally recognized that the field of

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combinatorics has, over the past years, evolved into a fully-fledged branch of discrete mathematics whose potential with respect to computers and the natural sciences is only beginning to be realized. Still, two points seem to bother most authors: The apparent difficulty in defining the scope of combinatorics and the fact that combinatorics seems to consist of a vast variety of more or less unrelated methods and results. As to the scope of the field, there appears to be a growing consensus that combinatorics should

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be divided into three large parts: (a) Enumeration, including generating functions, inversion, and calculus of finite differences; (b) Order Theory, including finite posets and lattices, matroids, and existence results such as Hall's and Ramsey's; (c) Configurations, including designs, permutation groups, and coding theory. The present book covers most aspects of parts (a) and (b), but none of (c). The reasons for excluding (c) were twofold. First, there exist several older books on the subject, such as Ryser [1] (which I still think is

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the most seductive introduction to combinatorics), Hall [2], and more recent ones such as Cameron-Van Lint [1] on groups and designs, and Blake-Mullin [1] on coding theory, whereas no comprehensive book exists on (a) and (b).

Theory and Practice of Combinatorics

A Very Short Introduction

A Course in Combinatorics

Combinatorial Matrix Classes

Inequalities

Field Theory and Its Classical Problems



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This long-awaited textbook is the most comprehensive introduction to a broad swath of combinatorial and discrete mathematics. The text covers enumeration, graphs, sets, and methods, and it includes both classic results and more recent developments. Assuming no prior exposure to combinatorics, it explains the basic material for graduate-level students in mathematics and computer science. Optional more advanced material also makes it valuable as a research reference. Suitable for one-year course or a one-semester introduction, this textbook prepares students to move on to more advanced material. It is organized to emphasize connections

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among the topics, and facilitate instruction, self-study and research, with more than 2200 exercises (many accompanied by hints) at various levels of difficulty. Consistent notation and terminology are used throughout, allowing for a discussion of diverse topics a unified language. The thorough bibliography, containing thousands of citations, makes this a valuable source for students and researchers alike.

Combinatorics, or the art and science of counting, is a vibrant and active area of pure mathematical research with many applications. The Unity of Combinatorics succeeds in showing that the many facets of

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combinatorics are not merely isolated instances of clever tricks but that they have numerous connections and threads weaving them together to form a beautifully patterned tapestry of ideas. Topics include combinatorial designs, combinatorial games, matroids, difference sets, Fibonacci numbers, finite geometries, Pascal's triangle, Penrose tilings, error-correcting codes, and many others. Anyone with an interest in mathematics, professional or recreational, will be sure to find this book both enlightening and enjoyable. Few mathematicians have been as active in this area as Richard Guy, now in his eighth decade of mathematical productivity. Guy is the

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author of over 300 papers and twelve books in geometry, number theory, graph theory, and combinatorics. In addition to being a life-long number-theorist and combinatorialist, Guy's co-author, Ezra Brown, is a multi-award-winning expository writer. Together, Guy and Brown have produced a book that, in the spirit of the founding words of the Carus book series, is accessible "not only to mathematicians but to scientific workers and others with a modest mathematical background."

This ENCYCLOPAEDIA OF MATHEMATICS aims to be a reference work for all parts of mathematics. It is

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translation with updates and editorial comments of the Soviet Mathematical Encyclopaedia published by 'Soviet Encyclopaedia Publishing House' in five volumes in 1977 - 1985. The annotated translation consists of ten volumes including a special index volume. There are three kinds of articles in this ENCYCLOPAEDIA. First of all there are survey-type articles dealing with the various main directions in mathematics (where a rather fine subdivision has been used). The main requirement for these articles has been that they should give a reasonably complete up-to-date account of the current state of affairs in these areas

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that they should be maximally accessible. On the whole these articles should be understandable to mathematicians in their first specialization years, to graduates from other mathematical areas and, depending on the specific subject, to specialists in other domains of science, engineers and teachers of mathematics. These articles treat their material at a fairly general level and aim to give an idea of the kind of problems, techniques and concepts involved in the area in question. They also contain background and motivation rather than precise statements of precise theorems with detailed definitions and technical details on how to carry out proofs and

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constructions. The second kind of article, of medium length, contains more detailed concrete problems, results and techniques.

This is the second edition of a popular book on combinatorics, a subject dealing with ways of arranging and distributing objects, and which involves ideas from geometry, algebra and analysis. The breadth of the theory is matched by that of its applications, which include topics as diverse as codes, circuit design and algorithm complexity. It has thus become essential for workers in many scientific fields to have some familiarity with the subject. The authors have tried to

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as comprehensive as possible, dealing in a unified manner with, for example, graph theory, extremal problems, designs, colorings and codes. The depth and breadth of the coverage make the book a unique guide to the whole of the subject. The book is ideal for courses in combinatorial mathematics at the advanced undergraduate or beginning graduate level. Working mathematicians and scientists will also find it a valuable introduction and reference.

Use of Mathematical Literature

A Tribute to Gian-Carlo Rota

Geometry and Combinatorics



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Combinatorial Geometry in the Plane  
Organic Mathematics

This book presents rigidity theory in a historical context. The combinatorial aspects of rigidity are isolated and framed in terms of a special class of matroids, which are a natural generalization of the connectivity matroid of a graph. The book includes an introduction to matroid theory and an extensive study of planar rigidity. The final chapter is devoted to higher dimensional rigidity, highlighting the main open questions. Also included is an extensive annotated bibliography with over 150 entries. The book is aimed

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at graduate students and researchers in graph theory and combinatorics or in fields which apply the structural aspects of these subjects in architecture and engineering. Accessible to those who have had an introduction to graph theory at the senior or graduate level, the book would be suitable for a graduate course in graph theory.

Use of Mathematical Literature discusses the bibliographic concerns of mathematical literature. The book is comprised of 14 chapters that cover characteristics of mathematical literature and provide reviews of some of the major literature in various mathematical fields. The text first discusses the role of

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the literature in mathematics, and then proceeds to tackling major organizations, journals, and reference materials. Next, the book provides critical accounts of the major literature in various mathematical fields, such as combinatorics, topology, and mathematical programming. The book will be of great use to students, practitioners, and researchers of mathematics. Other profession handling math literature, such as teachers, librarians, and translators will also find this book invaluable.

Combinatorics has come of age. It had its beginnings in a number of puzzles which have still not lost their charm. Among these are EULER'S problem of the 36

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officers and the KONIGSBERG bridge problem, BACHET's problem of the weights, and the Reverend T.P. KIRKMAN'S problem of the schoolgirls. Many of the topics treated in ROUSE BALL'S Recreational Mathematics belong to combinatorial theory. All of this has now changed. The solution of the puzzles has led to a large and sophisticated theory with many complex ramifications. And it seems probable that the four color problem will only be solved in terms of as yet undiscovered deep results in graph theory. Combinatorics and the theory of numbers have much in common. In both theories there are many problems which are easy to state in terms understandable by the

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layman, but whose solution depends on complicated and abstruse methods. And there are now interconnections between these theories in terms of which each enriches the other. Combinatorics includes a diversity of topics which do however have interrelations in superficially unexpected ways. The instructional lectures included in these proceedings have been divided into six major areas: 1. Theory of designs; 2. Graph theory; 3. Combinatorial group theory; 4. Finite geometry; 5. Foundations, partitions and combinatorial geometry; 6. Coding theory. They are designed to give an overview of the classical foundations of the subjects treated and also some

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indication of the present frontiers of research.

An introduction to the classical notions behind modern Galois theory.

Combinatorics

Information Sources for Research and Development

Combinatorial Designs for Authentication and Secrecy

Codes

Combinatorics and Graph Theory

Combinatorial Theory

Combinatorial Designs for Authentication and Secrecy Codes is a succinct in-depth review and tutorial of a subject that promises to lead to major advances in computer and communication security. This monograph provides a tutorial on combinatorial

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designs, which gives an overview of the theory. Furthermore, the application of combinatorial designs to authentication and secrecy codes is described in depth. This close relationship of designs with cryptography and information security was first revealed in Shannon's seminal paper on secrecy systems. We bring together in one source foundational and current contributions concerning design-theoretic constructions and characterizations of authentication and secrecy codes.

A collection of articles by leading experts in theoretical computer science, this volume commemorates the 75th birthday of Professor Rani Siromoney, one of the pioneers in the field in India. The articles span the vast range of areas that Professor Siromoney has worked in or influenced, including grammar

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systems, picture languages and new models of computation. Sample Chapter(s). Chapter 1: Finite Array Automata and Regular Array Grammars (150 KB). Contents: Finite Array Automata and Regular Array Grammars (A Atanasiu et al.); Hexagonal Contextual Array P Systems (K S Dersanambika et al.); Contextual Array Grammars (R Freund et al.); A Cosmic Muse (T Head); Triangular Pasting System (T Kalyani et al.); Petri Nets, Event Structures and Algebra (K Lodaya); Anchored Concatenation of MSCs (M Mukund et al.); On Languages Defined by Numerical Parameters (A Salomaa); Digitalization of Kolam Patterns and Tactile Kolam Tools (S Nagata & R Thamburaj); Pollard's Rho Split Knowledge Scheme (M K Viswanath & K P Vidya); and other papers. Readership:



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Researchers in computer science.

Geometry and Combinatorics: Selected Works of J. J. Seidel brings together some of the works of J. J. Seidel in geometry and combinatorics. Seidel's selected papers are divided into four areas: graphs and designs; lines with few angles; matrices and forms; and non-Euclidean geometry. A list of all of Seidel's publications is included. Comprised of 29 chapters, this book begins with a discussion on equilateral point sets in elliptic geometry, followed by an analysis of strongly regular graphs of L2-type and of triangular type. The reader is then introduced to strongly regular graphs with  $(-1, 1, 0)$  adjacency matrix having eigenvalue 3; graphs related to exceptional root systems; and equiangular lines. Subsequent chapters deal with the regular two-

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graph on 276 vertices; the congruence order of the elliptic plane; equi-isoclinic subspaces of Euclidean spaces; and Wielandt's visibility theorem. This monograph will be of interest to students and practitioners in the field of mathematics.

This volume is the hardcopy version of the electronic manuscript, Proceedings of the Organic Mathematics Workshop held at Simon Fraser University in December 1995

([www.cecm.sfu.ca/organics](http://www.cecm.sfu.ca/organics)). The book provides a fixed, easily referenced, and permanent version of what is otherwise an evolving document. Contained in this work is a collection of articles on experimental and computational mathematics contributed by leading mathematicians around the world. The papers span a variety of mathematical fields - from juggling to

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differential equations to prime number theory. The book also contains biographies and photos of the contributing mathematicians and an in-depth characterization of organic mathematics.

Theory of Majorization and Its Applications

Encyclopaedia of Mathematics

C An updated and annotated translation of the Soviet

‘ Mathematical Encyclopaedia ’

Algebraic Combinatorics and Computer Science

Formal Models, Languages and Applications

This book provides an introduction to quasigroup theory along with new structural results on some of the quasigroup classes. Many results are presented with

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some of them from mathematicians of the former USSR. These included results have not been published before in the western mathematical literature. In addition, many of the achievements obtained with regard to applications of quasigroups in coding theory and cryptology are described.

This volume is a record of the papers presented to the fourth British Combinatorial Conference held in Aberystwyth in July 1973. Contributors from all over the world took part and the result is a very useful and up-to-date account of what is happening in the field of combinatorics. A section of problems illustrates some of the topics in need of further investigation.

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Advanced undergraduate-level text discusses theorems on topics restricted to the plane, such as convexity, coverings, and graphs. Two-part treatment begins with specific topics followed by an extensive selection of short proofs. 1964 edition.

A natural sequel to the author's previous book *Combinatorial Matrix Theory* written with H. J. Ryser, this is the first book devoted exclusively to existence questions, constructive algorithms, enumeration questions, and other properties concerning classes of matrices of combinatorial significance. Several classes of matrices are thoroughly developed including the classes of matrices of 0's and 1's with a specified number of 1's

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in each row and column (equivalently, bipartite graphs with a specified degree sequence), symmetric matrices in such classes (equivalently, graphs with a specified degree sequence), tournament matrices with a specified number of 1's in each row (equivalently, tournaments with a specified score sequence), nonnegative matrices with specified row and column sums, and doubly stochastic matrices. Most of this material is presented for the first time in book format and the chapter on doubly stochastic matrices provides the most complete development of the topic to date.

Canadian Journal of Mathematics

The Unity of Combinatorics

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Advanced Modern Algebra: Third Edition, Part 2

Combinatorial Rigidity

A-Integral – Coordinates

Herbert J. Ryser is widely regarded as one of the major figures in combinatorics in the 20th century. His Combinatorial Mathematics is a classic which has enticed many young mathematics students into this area.

Combinatorial Mathematics American  
Mathematical Soc.

This concise, undergraduate-level text

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focuses on combinatorics, graph theory with applications to some standard network optimization problems, and algorithms. More than 200 exercises, many with complete solutions. 1991 edition.

A Trusted Guide to Discrete Mathematics with Proof? Now in a Newly Revised Edition Discrete mathematics has become increasingly popular in recent years due to its growing applications in the field of computer science. Discrete



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Mathematics with Proof, Second Edition continues to facilitate an up-to-date understanding of this important topic, exposing readers to a wide range of modern and technological applications. The book begins with an introductory chapter that provides an accessible explanation of discrete mathematics. Subsequent chapters explore additional related topics including counting, finite probability theory, recursion, formal models in computer science,

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graph theory, trees, the concepts of functions, and relations. Additional features of the Second Edition include: An intense focus on the formal settings of proofs and their techniques, such as constructive proofs, proof by contradiction, and combinatorial proofs. New sections on applications of elementary number theory, multidimensional induction, counting tulips, and the binomial distribution. Important examples from the field of

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computer science presented as applications including the Halting problem, Shannon's mathematical model of information, regular expressions, XML, and Normal Forms in relational databases Numerous examples that are not often found in books on discrete mathematics including the deferred acceptance algorithm, the Boyer-Moore algorithm for pattern matching, Sierpinski curves, adaptive quadrature, the Josephus problem, and the five-

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color theorem Extensive appendices that outline supplemental material on analyzing claims and writing mathematics, along with solutions to selected chapter exercises

Combinatorics receives a full chapter treatment that extends beyond the combinations and permutations material by delving into non-standard topics such as Latin squares, finite projective planes, balanced incomplete block designs, coding theory,

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partitions, occupancy problems, Stirling numbers, Ramsey numbers, and systems of distinct representatives. A related Web site features animations and visualizations of combinatorial proofs that assist readers with comprehension. In addition, approximately 500 examples and over 2,800 exercises are presented throughout the book to motivate ideas and illustrate the proofs and conclusions of theorems. Assuming only

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a basic background in calculus, Discrete Mathematics with Proof, Second Edition is an excellent book for mathematics and computer science courses at the undergraduate level. It is also a valuable resource for professionals in various technical fields who would like an introduction to discrete mathematics.

Invited Papers for the Ninth British Combinatorial Conference 1983  
Combinatorial Mathematics

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Discrete Mathematics with Proof  
Combinatorics Advances  
Elements of Quasigroup Theory and  
Applications

**These notes were first used in an introductory course team taught by the authors at Appalachian State University to advanced undergraduates and beginning graduates. The text was written with four pedagogical goals in mind: offer a variety of topics in one course, get to the main themes and**

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tools as efficiently as possible, show the relationships between the different topics, and include recent results to convince students that mathematics is a living discipline.

How many possible sudoku puzzles are there? In the lottery, what is the chance that two winning balls have consecutive numbers? Who invented Pascal's triangle? (it was not Pascal) Combinatorics, the branch of mathematics concerned with selecting,



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arranging, and listing or counting collections of objects, works to answer all these questions. Dating back some 3000 years, and initially consisting mainly of the study of permutations and combinations, its scope has broadened to include topics such as graph theory, partitions of numbers, block designs, design of codes, and latin squares. In this Very Short Introduction Robin Wilson gives an overview of the field and its applications in mathematics and

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computer theory, considering problems from the shortest routes covering certain stops to the minimum number of colours needed to colour a map with different colours for neighbouring countries. ABOUT THE SERIES: The Very Short Introductions series from Oxford University Press contains hundreds of titles in almost every subject area. These pocket-sized books are the perfect way to get ahead in a new subject quickly. Our expert authors

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combine facts, analysis, perspective,  
new ideas, and enthusiasm to make  
interesting and challenging topics  
highly readable.

**Combinatorial Matrix Theory**