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This book, based on the authors' lecture series at a 2006
satellite meeting of the International Congress of
Mathematicians, offers a comprehensive survey of core areas
of combinatorial geometry. These lecture notes aptly describe
both the history and the state of the art of these topics. These
combinatorial techniques have found applications in areas of
computer science ranging from graph drawing to frequency
allocation in cellular networks.

A complete, self-contained introduction to a powerful and

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resurging mathematical discipline. Combinatorial Geometry presents and explains with complete proofs some of the most important results and methods of this relatively young mathematical discipline, started by Minkowski, Fejes Toth, Rogers, and Erdős. Nearly half the results presented in this book were discovered over the past twenty years, and most have never before appeared in any monograph. Combinatorial Geometry will be of particular interest to mathematicians, computer scientists, physicists, and materials scientists interested in computational geometry, robotics, scene analysis, and computer-aided design. It is also a superb textbook, complete with end-of-chapter problems and hints to their solutions that help students clarify their understanding and test their mastery of the material. Topics covered include:

- * Geometric number theory
- * Packing and covering with congruent convex disks
- * Extremal graph and hypergraph theory
- * Distribution of distances among finitely many points
- * Epsilon-nets and Vapnik--Chervonenkis dimension
- * Geometric graph theory
- * Geometric discrepancy theory

And much more

Computational geometry as an area of research in its own right emerged in the early seventies of this century. Right from the beginning, it was obvious that strong connections of various kinds exist to questions studied in the considerably older field of combinatorial geometry. For example, the combinatorial structure of a geometric problem usually decides which algorithmic method solves the problem most efficiently. Furthermore, the analysis of an algorithm often requires a great deal of combinatorial knowledge. As it turns out, however, the connection between the two research areas commonly referred to as computational geometry and combinatorial geometry is not as lop-sided as it appears. Indeed, the interest in computational issues in geometry gives

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a new and constructive direction to the combinatorial study of geometry. It is the intention of this book to demonstrate that computational and combinatorial investigations in geometry are doomed to profit from each other. To reach this goal, I designed this book to consist of three parts, a combinatorial part, a computational part, and one that presents applications of the results of the first two parts. The choice of the topics covered in this book was guided by my attempt to describe the most fundamental algorithms in computational geometry that have an interesting combinatorial structure. In this early stage geometric transforms played an important role as they reveal connections between seemingly unrelated problems and thus help to structure the field.

Historically, there is a close connection between geometry and optimization. This is illustrated by methods like the gradient method and the simplex method, which are associated with clear geometric pictures. In combinatorial optimization, however, many of the strongest and most frequently used algorithms are based on the discrete structure of the problems: the greedy algorithm, shortest path and alternating path methods, branch-and-bound, etc. In the last several years geometric methods, in particular polyhedral combinatorics, have played a more and more profound role in combinatorial optimization as well. Our book discusses two recent geometric algorithms that have turned out to have particularly interesting consequences in combinatorial optimization, at least from a theoretical point of view. These algorithms are able to utilize the rich body of results in polyhedral combinatorics. The first of these algorithms is the ellipsoid method, developed for nonlinear programming by N. Z. Shor, D. B. Yudin, and A. S. Nemirovskii. It was a great surprise when L. G. Khachiyan showed that this method can be adapted to solve linear programs in polynomial time, thus

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Solving an important open theoretical problem. While the ellipsoid method has not proved to be competitive with the simplex method in practice, it does have some features which make it particularly suited for the purposes of combinatorial optimization. The second algorithm we discuss finds its roots in the classical "geometry of numbers", developed by Minkowski. This method has had traditionally deep applications in number theory, in particular in diophantine approximation.

Cuts and metrics are well-known objects that arise - independently, but with many deep and fascinating connections - in diverse fields: in graph theory, combinatorial optimization, geometry of numbers, combinatorial matrix theory, statistical physics, VLSI design etc. This book presents a wealth of results, from different mathematical disciplines, in a unified comprehensive manner, and establishes new and old links, which cannot be found elsewhere. It provides a unique and invaluable source for researchers and graduate students. From the Reviews: "This book is definitely a milestone in the literature of integer programming and combinatorial optimization. It draws from the Interdisciplinarity of these fields [...]. With knowledge about the relevant terms, one can enjoy special subsections without being entirely familiar with the rest of the chapter. This makes it not only an interesting research book but even a dictionary. [...] The longer one works with it, the more beautiful it becomes." Optima 56, 1997.

In many applications of graph theory, graphs are regarded as geometric objects drawn in the plane or in some other surface. The traditional methods of "abstract" graph theory are often incapable of providing satisfactory answers to questions arising in such applications. In the past couple of

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decades, many powerful new combinatorial and topological techniques have been developed to tackle these problems. Today geometric graph theory is a burgeoning field with many striking results and appealing open questions. This contributed volume contains thirty original survey and research papers on important recent developments in geometric graph theory. The contributions were thoroughly reviewed and written by excellent researchers in this field.

This 2005 book deals with interest topics in Discrete and Algorithmic aspects of Geometry.

Graphs are usually represented as geometric objects drawn in the plane, consisting of nodes and curves connecting them. The main message of this book is that such a representation is not merely a way to visualize the graph, but an important mathematical tool. It is obvious that this geometry is crucial in engineering, for example, if you want to understand rigidity of frameworks and mobility of mechanisms. But even if there is no geometry directly connected to the graph-theoretic problem, a well-chosen geometric embedding has mathematical meaning and applications in proofs and algorithms. This book surveys a number of such connections between graph theory and geometry: among others, rubber band representations, coin representations, orthogonal representations, and discrete analytic functions. Applications are given in information theory, statistical physics, graph algorithms and quantum physics. The book is based on courses and lectures that the author has given over the last few decades and offers readers with some knowledge of graph theory, linear algebra, and probability a thorough introduction to this exciting new area with a large collection of illuminating examples and exercises.

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This volume is the first comprehensive treatment of combinatorial algebraic topology in book form. The first part of the book constitutes a swift walk through the main tools of algebraic topology. Readers - graduate students and working mathematicians alike - will probably find particularly useful the second part, which contains an in-depth discussion of the major research techniques of combinatorial algebraic topology. Although applications are sprinkled throughout the second part, they are principal focus of the third part, which is entirely devoted to developing the topological structure theory for graph homomorphisms.

What is the "most uniform" way of distributing n points in the unit square? How big is the "irregularity" necessarily present in any such distribution? This book is an accessible and lively introduction to the area of geometric discrepancy theory, with numerous exercises and illustrations. In separate, more specialized parts, it also provides a comprehensive guide to recent research.

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