Prefaces

Preface to the English Translation

The book that you hold in your hands is based on the 5th edition of the German text "Diskrete Mathematik" published by Vieweg-Verlag. The translator, David Kramer, has done an admirable job; he not only perfectly conveyed the spirit of the original, but improved the text in several points. My sincere thanks go to him and to Ina Mette, who initiated this project. The intentions and scope of the book are explained extensively in the preface to the first edition. It is my hope that readers will learn about the most important developments of discrete mathematics, and at the same time enjoy the subject as an intuitively appealing mathematical pleasure.

Translator's Note

I would like to express my thanks to those who have made my work on this translation the great pleasure that it was: to Ina Mette, of the American Mathematical Society, who invited me to take on this project and who has supported my work over the past year; to Martin Aigner, who way beyond the call of duty read the entire translation, correcting a number of errors and answering my queries when I got stuck; to Arlene O'Sean for copyediting; and to Barbara Beeton and Stephen Moye for TeX-nical support.

Preface to the First Edition

Fifty years ago, there was no concept of "discrete mathematics," and even today it is not a commonplace in German-speaking countries. Courses in discrete mathematics are not universally available, and certainly not with a comprehensive list of topics (in contrast, for example, to the USA, where it has long since established a permanent place for itself). Mathematicians generally understand “discrete mathematics” to mean combinatorics or graph theory, while computer scientists think of discrete structures or Boolean algebras. This book therefore has the goal of presenting all the topics necessary for further study in these areas.

Discrete mathematics deals primarily with finite sets. And what can one study in relation to finite set? First of all, one can count them, which is the classical theme of combinatorics. In Part 1 we shall learn about all the most important ideas and methods of *counting*. Depending on the problem, one is generally presented with a simple structure on a collection of finite sets in the form of relations. Graphs, which have the greatest scope of application, are an example of this. These aspects will be presented in Part 2 under the rubric of *graphs and algorithms*. Finally, there is often an algebraic structure on finite sets (or one may supply one in a natural way). *Algebraic systems* are the content of Part 3.

These three points of view form the Ariadne’s thread that runs throughout this book. Another aspect that permeates our presentation has to do with the notion of optimization. The development that has completely revolutionized combinatorics over the past fifty years, bringing about the field of discrete mathematics, was the search for efficient algorithms. It no longer sufficed to solve a problem theoretically; one now wished to construct an explicit solution, and if possible using a fast algorithm. It is certainly not by chance that this optimization point of view gained ascendance at the end of the 1940s, exactly at the time of the development of the first fast computers. Therefore, we shall place great emphasis in this book on the algorithmic point of view, above all in Part 2, as announced in the title of that part. Discrete mathematics today is a basic science for information theory, and the topics covered in this book should be of equal interest to mathematicians and computer scientists.

The three parts are organized in such a way that except for Chapters 1 and 6—which deal respectively with the fundamentals of counting and graphs and should be read by all readers—they can be studied independently of one another. All the material can be covered in a two-semester course, while Chapters 1–3, 6–8, and 13 could form the content for a one-semester course. It is usual in a preface to a textbook like this for the author to point out the importance of working the exercises. In a book on discrete mathematics one cannot stress too highly the value of the exercises, which should be clear from the fact that the exercises and solutions take up almost one-fourth of the book. Discrete mathematics deals above all with concrete problems, and without practice, one will be unable to solve them despite all one's theoretical knowledge. Furthermore, the exercises often suggest questions that lead more deeply into the subject. The exercises in each chapter are divided (by a horizontal line) into two parts. Those of the first part should be relatively easy to solve, while those of the second are more difficult. Many exercises contain hints, and those indicated with $\triangleright$ have a solution at the end of the book. Each part ends with a brief bibliography with some suggestions for further study.

The only prerequisites for this book are familiarity with mathematical fundamentals and in a number of places some knowledge of linear algebra and calculus at the undergraduate level. The notation used is generally standard, with perhaps the following exceptions:

$A = \sum A_i$	the set A is the *disjoint union* of the A_i,
$A = \prod A_i$	the set A is the *Cartesian product* of the A_i,
$\binom{A}{k}$	the family of all k-subsets of A.

The advantage of this notation is that it carries over immediately to the size of the sets:

$$\left|\sum A_i\right| = \sum |A_i|, \quad \left|\prod A_i\right| = \prod |A_i|, \quad \left|\binom{A}{k}\right| = \binom{|A|}{k}.$$

If the sets A_i are not necessarily disjoint, then we set as usual $A = \bigcup A_i$. The elements of $\prod A_i = A_1 \times \cdots \times A_n$ are as usual all n-tuples $(a_1, \ldots, a_n)$, $a_i \in A$. A k-set consists of k elements, and $\mathcal{B}(S)$ is the family of all subsets of S. The notation $\lceil x \rceil$, $\lfloor x \rfloor$ for $x \in \mathbb{R}$ means x rounded up, respectively down, to the next integer. Finally $|S|$ denotes the number of elements of the set S.

This book is the result of a course that I have given for students in mathematics and computer science. I am grateful for the collaboration (and criticism) of these students. I offer particular thanks to my colleague G. Stroth and my students T. Biedl, A. Lawrenz, and H. Mielke, who read through the entire text and made improvements in many places. My wholehearted thanks go to E. Greene, S. Hoemke, and M. Barrett for their transformation of the manuscript into LaTeX, and to Vieweg-Verlag for their helpful and friendly collaboration.

Berlin, Easter 1993 Martin Aigner

Preface to the Fifth Edition

In the last few years, discrete mathematics has established itself as a basic subject in mathematics and computer science. There is a more or less agreed-upon set of standard topics, and the connections to other areas, primarily theoretical computer science, have been made to the benefit of all parties. If it is not too presumptuous of me to put a favorable interpretation on the many complimentary remarks and suggestions about this book, then it, too, since its appearance a decade ago, has contributed a little to this happy development.

The present edition represents a thorough revision and expansion. There are two new chapters: one on counting patterns with symmetries, which offers access to the most elegant theorems of combinatorics; the other resulting from the split of the chapter on codes into one on coding and the other on cryptography, not least because of the great significance of these topics in discussions both inside and outside mathematics. And finally, there are one hundred new exercises to give the reader something to think about and to encourage him or her to further study.

Like the first edition, this one was carefully composed by Margrit Barrett in LaTeX. I offer her my hearty thanks, and also Christoph Eyrich, who did the the final editing, and Frau Schmickler-Hirzebruch, of Vieweg-Verlag, for her friendly collaboration.

Berlin, December 2003 Martin Aigner