# Preface

Factorial designs are widely used in many scientific and industrial investigations. The objective of this book is to provide a rigorous, systematic, and up-to-date treatment of the theoretical aspects of this subject. Despite its long history, research in factorial design has grown considerably in the past two decades. Several books covering these advances are available; nevertheless new discoveries continued to emerge. There are also useful old results that seem to have been overlooked in recent literature and, in my view, deserve to be better known.

Factorial experiments with multiple error terms (strata) that result from complicated structures of experimental units are common in agriculture. In recent years, the design of such experiments also received much attention in industrial applications. A theory of orthogonal block structures that goes back to John Nelder provides a unifying framework for the design and analysis of multi-stratum experiments. One feature of the present book is to present this elegant and general theory which, once understood, is simple to use, and can be applied to various structures of experimental units in a unified and systematic way. The mathematics required to understand this theory is perhaps what, in Rosemary Bailey's words, "obscured the essential simplicity" of the theory. In this book, I tried to minimize the mathematics needed, and did not present the theory in the most general form as developed by Bailey and her coauthors. To prepare readers for the general theory, a unified treatment of some simple designs such as completely randomized designs, block designs, and row-column designs is presented first. Therefore the book also covers these elementary non-factorial-design topics. It is suitable as a reference book for researchers and as a textbook for graduate students who have taken a first course in the design of experiments. Since the book is self-contained and includes many examples, it should also be accessible to readers with minimal previous exposure to experimental design as long as they have good mathematical and statistical backgrounds. Readers are required to be familiar with linear algebra. A review of linear model theory is given in Chapter 2, and a brief survey of some basic algebraic results on finite groups and fields can be found in the Appendix. Sections that can be skipped, at least on the first reading, without affecting the understanding of the material in later parts of the book are marked with stars.

In addition to a general theory of multi-stratum factorial design, the book covers many other topics and results that have not been reported in books. These include, among others, the useful method of design key for constructing multi-stratum factorial designs, the methods of partial foldover and doubling for constructing two-level resolution IV designs, some results on the structures of two-level resolution IV designs taken from the literature of projective geometry, the extension of minimum

aberration to nonregular designs, and the minimum moment aberration criterion, which is equivalent to minimum aberration.

The book does not devote much space to the analysis of factorial designs due to its theoretical nature, and also because excellent treatment of strategies for data analysis can be found in several more applied books. Another subject that does not receive a full treatment is the so-called nonregular designs. It is touched upon in Chapter 8 when orthogonal arrays are introduced, and some selected topics are surveyed in Chapter 15. The research on nonregular designs is still very active and expands rapidly. It deserves another volume.

The writing of this book originated from a ten-lecture workshop on "Recent Developments in Factorial Design" I gave in June 2002 at the Institute of Statistical Science, Academia Sinica, in Taiwan. I thank Chen-Hsin Chen, Director of the institute at the time, for his invitation. The book was written over a long period of time while I taught at the University of California, Berkeley, and also during visits to the National Center for Theoretical Sciences in Hsinchu, Taiwan, and the Issac Newton Institute for Mathematical Sciences in Cambridge, United Kingdom. The support of these institutions and the US National Science Foundation is acknowledged. The book could not have been completed without the help of many people. It contains results from joint works with Rosemary Bailey, Dursun Bulutoglu, Hegang Chen, Lih-Yuan Deng, Mike Jacroux, Bobby Mee, Rahul Mukerjee, Nam-Ky Nguyen, David Steinberg, Don Sun, Boxin Tang, Pi-Wen Tsai, Hongquan Xu, and Oksoun Yee. I had the privilege of working with them. I also had the fortune to know Rosemary Bailey early in my career. Her work has had a great impact on me, and this book uses the framework she had developed. Boxin Tang read the entire book, and both Rosemary Bailey and Don Ylvisaker read more than half of it. They provided numerous detailed and very helpful comments as well as pointing out many errors. Hegang Chen, Chen-Tuo Liao, and Hongquan Xu helped check the accuracy of some parts of the book. As a LaTex novice, I am very grateful to Pi-Wen Tsai for her help whenever I ran into problems with LaTex. She also read and commented on earlier versions of several chapters. Yu-Ting Chen and Chiun-How Kao helped fix some figures. I would also like to acknowledge our daughter Adelaide for her endearing love and support as well as her upbeat reminder to always see the bright side. Last but not least, I am most grateful to my wife Suzanne Pan for her thankless support and care over the years and for patiently reading this "Tian Shu" from cover to cover.

Additional material for the book will be maintained at http://www.crcpress.com/product/isbn/9781466505575/ and http://www.stat.sinica.edu.tw/factorial-design/.