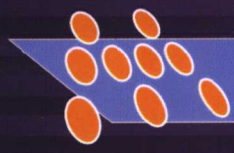

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影印版

Probability and Statistics

For Engineering and The Sciences (Fifth Edition)

概率论与数理统计

(第5版)

JAY L. DEVORE

高等教育出版社
Higher Education Press

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出版者的话

在我国已经加入 WTO、经济全球化的今天，为适应当前我国高校各类创新人才培养的需要，大力推进教育部倡导的双语教学，配合教育部实施的“高等学校教学质量与教学改革工程”和“精品课程”建设的需要，高等教育出版社有计划、大规模地开展了海外优秀数学类系列教材的引进工作。

高等教育出版社和 Pearson Education，John Wiley & Sons，McGraw-Hill，Thomson Learning 等国外出版公司进行了广泛接触，经国外出版公司的推荐并在国内专家的协助下，提交引进版权总数 100 余种。收到样书后，我们聘请了国内高校一线教师、专家、学者参与这些原版教材的评介工作，并参考国内相关专业的课程设置和教学实际情况，从中遴选出了这套优秀教材组织出版。

这批教材普遍具有以下特点：（1）基本上是近 3 年出版的，在国际上被广泛使用，在同类教材中具有相当的权威性；（2）高版次，历经多年教学实践检验，内容翔实准确、反映时代要求；（3）各种教学资源配套整齐，为师生提供了极大的便利；（4）插图精美、丰富，图文并茂，与正文相辅相成；（5）语言简练、流畅、可读性强，比较适合非英语国家的学生阅读。

本系列丛书中，有 Finney、Weir 等编的《托马斯微积分》（第 10 版，Pearson），其特色可用“呈传统特色、富革新精神”概括，本书自 20 世纪 50 年代第 1 版以来，平均每四五年就有一个新版面世，长达 50 余年始终盛行于西方教坛，作者既有相当高的学术水平，又热爱教学，长期工作在教学第一线，其中，年近 90 的 G. B. Thomas 教授长年在 MIT 工作，具有丰富的教学经验；Finney 教授也在 MIT 工作达 10 年；Weir 是美国数学建模竞赛委员会主任。Stewart 编的立体化教材《微积分》（第 5 版，Thomson Learning）配备了丰富的教学资源，是国际上最畅销的微积分原版教材，2003 年全球销量约 40 余万册，在美国，占据了约 50%～60%的微积分教材市场，其用户包括耶鲁等名牌院校及众多一般院校 600 余所。本系列丛书还包括 Anton 编的经典教材《线性代数及其应用》（第 8 版，Wiley）；Jay L. Devore 编的优秀教材《概率论与数理统计》（第 5 版，Thomson Learning）等。在努力降低引进教材售价方面，高等教育出版社做了大量和细致的工作，这套引进的教材体现了一定的权威性、系统性、先进性和经济性等特点。

通过影印、翻译、编译这批优秀教材，我们一方面要不断地分析、学习、消化吸收国外优秀教材的长处，吸取国外出版公司的制作经验，提升我们自编教材的立体化配套标准，使我国高校教材建设水平上一个新的台阶；与此同时，我们还将尝试组织海外作者和国内作者合编外文版基础课数学教材，并约请国内专家改编部分国外优秀教材，以适应我国实际教学环境。

这套教材出版后，我们将结合各高校的双语教学计划，开展大规模的宣传、培训工作，及时地将本套丛书推荐给高校使用。在使用过程中，我们衷心希望广大高校教师和同学提出宝贵的意见和建议，如有好的教材值得引进，请与高等教育出版社高等理科分社联系，联系电话：010-58581384，E-mail: xuke@hep.com.cn。

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2004 年 4 月 20 日

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To my wife, Carol:
Your dedication to teaching
is a continuing inspiration to me.

To my daughters, Allison and Teresa:
The great pride I take in your
accomplishments knows no bounds.

Preface

Purpose

The use of probability models and statistical methods for analyzing data has become common practice in virtually all scientific disciplines. This book attempts to provide a comprehensive introduction to those models and methods most likely to be encountered and used by students in their careers in engineering and the natural sciences. Although the examples and exercises have been designed with scientists and engineers in mind, most of the methods covered are basic to statistical analyses in many other disciplines, so that students of business and the social sciences will also profit from reading the book.

Approach

Students in a statistics course designed to serve other majors may be initially skeptical of the value and relevance of the subject matter, but my experience is that students *can* be turned on to statistics by the use of good examples and exercises that blend their everyday experiences with their scientific interests. Consequently, I have worked hard to find examples of real, rather than artificial, data—data that someone thought was worth collecting and analyzing. Many of the methods presented, especially in the later chapters on statistical inference, are illustrated by analyzing data taken from a published source, and many of the exercises also involve working with such data. Sometimes the reader may be unfamiliar with the context of a particular problem (as indeed I often was), but I have found that students are more attracted by real problems with a somewhat strange context than by patently artificial problems in a familiar setting.

Mathematical Level

The exposition is relatively modest in terms of mathematical development. Substantial use of the calculus is made only in Chapter 4 and parts of Chapters 5 and 6. In particular, with the exception of an occasional remark or aside, calculus appears in the inference part of the book only in the second section of Chapter 6. Matrix algebra is not used at all. Thus almost all the exposition should be accessible to those whose mathematical background includes one semester or two quarters of differential and integral calculus.

Content

Chapter 1 begins with some basic concepts and terminology—population, sample, descriptive and inferential statistics, enumerative versus analytic studies, and so on—and continues with a survey of important graphical and numerical descriptive methods. A rather traditional development of probability is given in Chapter 2, followed by probability distributions of discrete and continuous random variables in Chapters 3 and 4, respectively. Joint distributions and their properties are discussed in the first part of Chapter 5. The latter part of this chapter introduces statistics and their sampling distributions, which form the bridge between probability and inference. The next three chapters cover point estimation, statistical intervals, and hypothesis testing based on a single sample. Methods of inference involving two independent samples and paired data are presented in Chapter 9. The analysis of variance is the subject of Chapters 10 and 11 (single-factor and multifactor, respectively). Regression makes its initial appearance in Chapter 12 (the simple linear regression model and correlation) and returns for an extensive encore in Chapter 13. The last three chapters develop chi-squared methods, distribution-free (nonparametric) procedures, and techniques from statistical quality control.

Helping Students Learn

Although the book's mathematical level should give most science and engineering students little difficulty, working toward an understanding of the concepts and gaining an appreciation for the logical development of the methodology may sometimes require substantial effort. To help students gain such an understanding and appreciation, I have provided numerous exercises ranging in difficulty from many that involve routine application of text material to some that ask the reader to extend concepts discussed in the text to somewhat new situations. There are many more exercises than most instructors would want to assign during any particular course, but I recommend that students be required to work a substantial number of them; in a problem-solving discipline, active involvement of this sort is the surest way to identify and close the gaps in understanding that inevitably arise. Answers to odd-numbered exercises appear in the answer section at the back of the text. In addition, a Student Solutions Manual, consisting of worked-out solutions to virtually all the odd-numbered exercises, is available.

New for This Edition

- The first section of Chapter 1 has been rewritten to emphasize from the outset that variation is the source from which all statistical methodology flows. The techniques from exploratory and descriptive statistics introduced in this chapter are utilized to a greater extent than before in the inferential part of the book.
- The material on sampling distributions in Chapter 5 has been reorganized to convey more clearly the central idea on which inferential methods are based: The value of any statistic (quantity calculated from sample data) will in general vary when sample after sample is selected from the same population.
- One-sided confidence and prediction intervals are now featured in Chapter 7 along with their two-sided counterparts. A new confidence interval for a population propor-

tion (the Agresti–Coull "score" interval) is included. Normal tolerance intervals, previously relegated to an exercise, are now discussed in more detail in the text itself, and a table of tolerance critical values for one- and two-sided intervals is included.

- There is increased emphasis on *P*-values for testing hypotheses. The appendix now contains a table of t curve tail areas, so that a statement such as $P\text{-value} \approx .017$, rather than just $.01 < P\text{-value} < .025$, can be made. A new chi-squared table also allows for more precise *P*-value information for chi-squared tests, and a more detailed F table does the same thing for F tests.
- Notation in the regression chapters has been streamlined, allowing for the use of more concise formulas. There is now a short subsection in Chapter 13 on logistic regression.
- Finally, numerous examples have been updated, and many new exercises have supplemented or replaced those from previous editions.

Recommended Coverage

There is enough material in this book for a year-long course. Anyone teaching a course of shorter duration will have to be selective in the choice of topics to be included. At Cal Poly, we teach a two-quarter sequence, meeting four hours per week. During the first ten weeks we cover much of the material in Chapters 1–7 (going lightly over joint distributions and the details of estimation by maximum likelihood and the method of moments). The second quarter begins with hypothesis testing and moves on to two-sample inferences, ANOVA, regression, and selections from the chi-squared, distribution-free, and quality control chapters. Coverage of material in a one-semester course would obviously have to be somewhat more restrictive. There is, of course, never enough time to teach students all that we would like them to know!

Acknowledgments

My colleagues here at Cal Poly have provided me with invaluable support and encouragement over the years. I am also grateful to the many users of previous editions who have made suggestions for improvement (and pointed out occasional errors). A note of thanks goes to Julie Seely and Beth Eltinge for their work on the Student Solutions Manual.

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I very much appreciate the editorial and production services provided by Susan Reiland, Christine Levesque, and Lori Heckelman (I can't conceive of a more effective and congenial production coordinator than Susan). The staff at Duxbury and Brooks/Cole has as usual been extremely supportive—thanks in particular to Carolyn Crockett, Curt Hinrichs, Tessa Avila, Seema Atwal, and Kimberly Raburn. I wish also to commend the sales representatives of Thomson Learning for their hard work over the years in getting the word out about earlier editions of this book as well as other books I have written. Finally, words cannot adequately express my gratitude toward my wife, Carol, for her support of my writing efforts over the course of the last 25 years.

Jay L. Devore

FIFTH EDITION

Probability and Statistics for Engineering and the Sciences

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