

The book cover features a collage of images related to science, education, and data analysis. It includes a student in a library, a hand holding a pen, a person using a microscope, a group of students at a computer, and a teacher at a whiteboard. The background is a light green with faint mathematical formulas and a large, stylized number '2'.

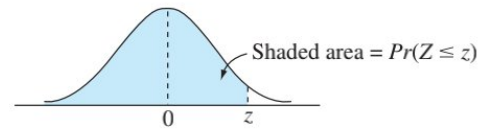
SIXTH EDITION

An Introduction to Statistical Methods and Data Analysis

R. Lyman Ott
Michael Longnecker

TABLE 1

Standard normal curve areas



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
-3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
-3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
-3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
-3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
-2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
-2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
-2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
-2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
-2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
-2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
-2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
-2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
-2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
-2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
-1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
-1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
-1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
-1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
-1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
-1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
-1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
-1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
-1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
-1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
-.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
-.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
-.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
-.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
-.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
-.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
-.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
-.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
-.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
-.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641
z	Area									
-3.50	.00023263									
-4.00	.00003167									
-4.50	.00000340									
-5.00	.00000029									
$-\infty$.00000000									

Source: Computed by M. Longnecker using the R function pnorm (z).

TABLE 1
(continued)

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998
z	Area									
3.50	.99976737									
4.00	.99996833									
4.50	.99999660									
5.00	.99999971									
∞	1.0									



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An Introduction to Statistical Methods and Data Analysis

Sixth Edition

R. Lyman Ott

Michael Longnecker
Texas A&M University



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Library of Congress Control Number: 2008931280

ISBN-13: 978-0-495-01758-5

ISBN-10: 0-495-01758-2

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Preface

Intended Audience

An Introduction to Statistical Methods and Data Analysis, Sixth Edition, provides a broad overview of statistical methods for advanced undergraduate and graduate students from a variety of disciplines. This book is intended to prepare students to solve problems encountered in research projects, to make decisions based on data in general settings both within and beyond the university setting, and finally to become critical readers of statistical analyses in research papers and in news reports. The book presumes that the students have a minimal mathematical background (high school algebra) and no prior course work in statistics. The first eleven chapters of the textbook present the material typically covered in an introductory statistics course. However, this book provides research studies and examples that connect the statistical concepts to data analysis problems, which are often encountered in undergraduate capstone courses. The remaining chapters of the book cover regression modeling and design of experiments. We develop and illustrate the statistical techniques and thought processes needed to design a research study or experiment and then analyze the data collected using an intuitive and proven four-step approach. This should be especially helpful to graduate students conducting their MS thesis and PhD dissertation research.

Major Features of Textbook

Learning from Data

In this text, we approach the study of statistics by considering a four-step process by which we can learn from data:

1. Designing the Problem
2. Collecting the Data
3. Summarizing the Data
4. Analyzing Data, Interpreting the Analyses, and Communicating the Results

Case Studies

In order to demonstrate the relevance and critical nature of statistics in solving real-world problems, we introduce the major topic of each chapter using a case study. The case studies were selected from many sources to illustrate the broad applicability of statistical methodology. The four-step learning from data process is illustrated through the case studies. This approach will hopefully assist in overcoming the natural initial perception held by many people that statistics is just another “math course.” The introduction of major topics through the use of case studies provides a focus of the central nature of applied statistics in a wide variety of research and business-related studies. These case studies will hopefully provide the reader with an enthusiasm for the broad applicability of statistics and the statistical thought process that the authors have found and used through their many years of teaching, consulting, and R & D management. The following research studies illustrate the types of studies we have used throughout the text.

- **Exit Poll versus Election Results:** A study of why the exit polls from 9 of 11 states in the 2004 presidential election predicted John Kerry as the winner when in fact President Bush won 6 of the 11 states.
- **Evaluation of the Consistency of Property Assessors:** A study to determine if county property assessors differ systematically in their determination of property values.
- **Effect of Timing of the Treatment of Port-Wine Stains with Lasers:** A prospective study that investigated whether treatment at a younger age would yield better results than treatment at an older age.
- **Controlling for Student Background in the Assessment of Teachers:** An examination of data used to support possible improvements to the No Child Left Behind program while maintaining the important concepts of performance standards and accountability.

Each of the research studies includes a discussion of the whys and hows of the study. We illustrate the use of the four-step learning from data process with each case study. A discussion of sample size determination, graphical displays of the data, and a summary of the necessary ingredients for a complete report of the statistical findings of the study are provided with many of the case studies.

Examples and Exercises

We have further enhanced the practical nature of statistics by using examples and exercises from journal articles, newspapers, and the authors’ many consulting experiences. These will provide the students with further evidence of the practical usages of statistics in solving problems that are relevant to their everyday life. Many new exercises and examples have been included in this edition of the book. The number and variety of exercises will be a great asset to both the instructor and students in their study of statistics. In many of the exercises we have provided computer output for the students to use in solving the exercises. For example, in several exercises dealing with designed experiments, the SAS output is given, including the AOV tables, mean separations output, profile plot, and residual analysis. The student is then asked a variety of questions about the experiment, which would be some of the typical questions asked by a researcher in attempting to summarize the results of the study.

Topics Covered

This book can be used for either a one-semester or two-semester course. Chapters 1 through 11 would constitute a one-semester course. The topics covered would include:

- Chapter 1—Statistics and the scientific method
- Chapter 2—Using surveys and experimental studies to gather data
- Chapters 3 & 4—Summarizing data and probability distributions
- Chapters 5–7—Analyzing data: inferences about central values and variances
- Chapters 8 & 9—One way analysis of variance and multiple comparisons
- Chapter 10—Analyzing data involving proportions
- Chapter 11—Linear regression and correlation

The second semester of a two-semester course would then include model building and inferences in multiple regression analysis, logistic regression, design of experiments, and analysis of variance:

- Chapters 11, 12, & 13—Regression methods and model building: multiple regression and the general linear model, logistic regression, and building regression models with diagnostics
- Chapters 14–18—Design of experiments and analysis of variance: design concepts, analysis of variance for standard designs, analysis of covariance, random and mixed effects models, split-plot designs, repeated measures designs, crossover designs, and unbalanced designs.

Emphasis on Interpretation, not Computation

In the book are examples and exercises that allow the student to study how to calculate the value of statistical estimators and test statistics using the definitional form of the procedure. After the student becomes comfortable with the aspects of the data the statistical procedure is reflecting, we then emphasize the use of computer software in making computations in the analysis of larger data sets. We provide output from three major statistical packages: SAS, Minitab, and SPSS. We find that this approach provides the student with the experience of computing the value of the procedure using the definition; hence the student learns the basics behind each procedure. In most situations beyond the statistics course, the student should be using computer software in making the computations for both expedience and quality of calculation. In many exercises and examples the use of the computer allows for more time to emphasize the interpretation of the results of the computations without having to expend enormous time and effort in the actual computations.

In numerous examples and exercises the importance of the following aspects of hypothesis testing are demonstrated:

1. The statement of the research hypothesis through the summarization of the researcher's goals into a statement about population parameters.
2. The selection of the most appropriate test statistic, including sample size computations for many procedures.

3. The necessity of considering both Type I and Type II error rates (α and β) when discussing the results of a statistical test of hypotheses.
4. The importance of considering both the statistical significance of a test result and the practical significance of the results. Thus, we illustrate the importance of estimating effect sizes and the construction of confidence intervals for population parameters.
5. The statement of the results of the statistical in nonstatistical jargon that goes beyond the statements “reject H_0 ” or “fail to reject H_0 .”

New to the Sixth Edition

- A research study is included in each chapter to assist students to appreciate the role applied statistics plays in the solution of practical problems. Emphasis is placed on illustrating the steps in the learning from data process.
- An expanded discussion on the proper methods to design studies and experiments is included in Chapter 2.
- Emphasis is placed on interpreting results and drawing conclusions from studies used in exercises and examples.
- The formal test of normality and normal probability plots are included in Chapter 4.
- An expanded discussion of logistic regression is included in Chapter 12.
- Techniques for the calculation of sample sizes and the probability of Type II errors for the t test and F test, including designs involving the one-way AOV and factorial treatment structure, are provided in Chapters 5, 6, and 14.
- Expanded and updated exercises are provided; examples and exercises are drawn from various disciplines, including many practical real-life problems.
- Discussion of discrete distributions and data analysis of proportions has been expanded to include the Poisson distribution, Fisher exact test, and methodology for combining 2×2 contingency tables.
- Exercises are now placed at the end of each chapter for ease of usage.

Additional Features Retained from Previous Editions

- Many practical applications of statistical methods and data analysis from agriculture, business, economics, education, engineering, medicine, law, political science, psychology, environmental studies, and sociology have been included.
- Review exercises are provided in each chapter.
- Computer output from Minitab, SAS, and SPSS is provided in numerous examples and exercises. The use of computers greatly facilitates the use of more sophisticated graphical illustrations of statistical results.
- Attention is paid to the underlying assumptions. Graphical procedures and test procedures are provided to determine if assumptions have been violated. Furthermore, in many settings, we provide alternative procedures when the conditions are not met.

- The first chapter provides a discussion of “What is statistics?” We provide a discussion of why students should study statistics along with a discussion of several major studies which illustrate the use of statistics in the solution of real-life problems.

Ancillaries

- Student Solutions Manual (ISBN-10: 0-495-10915-0; ISBN-13: 978-0-495-10915-0), containing select worked solutions for problems in the textbook.
- A Companion Website at www.cengage.com/statistics/ott, containing downloadable data sets for Excel, Minitab, SAS, SPSS, and others, plus additional resources for students and faculty.
- Solution Builder, available to instructors who adopt the book at www.cengage.com/solutionbuilder. This online resource contains complete worked solutions for the text available in customizable format outputted to PDF or to a password-protected class website.

Acknowledgments

There are many people who have made valuable constructive suggestions for the development of the original manuscript and during the preparation of the subsequent editions. Carolyn Crockett, our editor at Brooks/Cole, has been a tremendous motivator throughout the writing of this edition of the book. We are very appreciative of the insightful and constructive comments from the following reviewers:

Mark Ecker, University of Northern Iowa

Yoon G. Kim, Humboldt State University

Monnie McGee, Southern Methodist University

Ofer Harel, University of Connecticut

Mosuk Chow, Pennsylvania State University

Juanjuan Fan, San Diego State University

Robert K. Smidt, California Polytechnic State University

Mark Rizzardi, Humboldt State University

Soloman W. Harrar, University of Montana

Bruce Trumbo, California State University—East Bay