

# Elementary **STATISTICS**

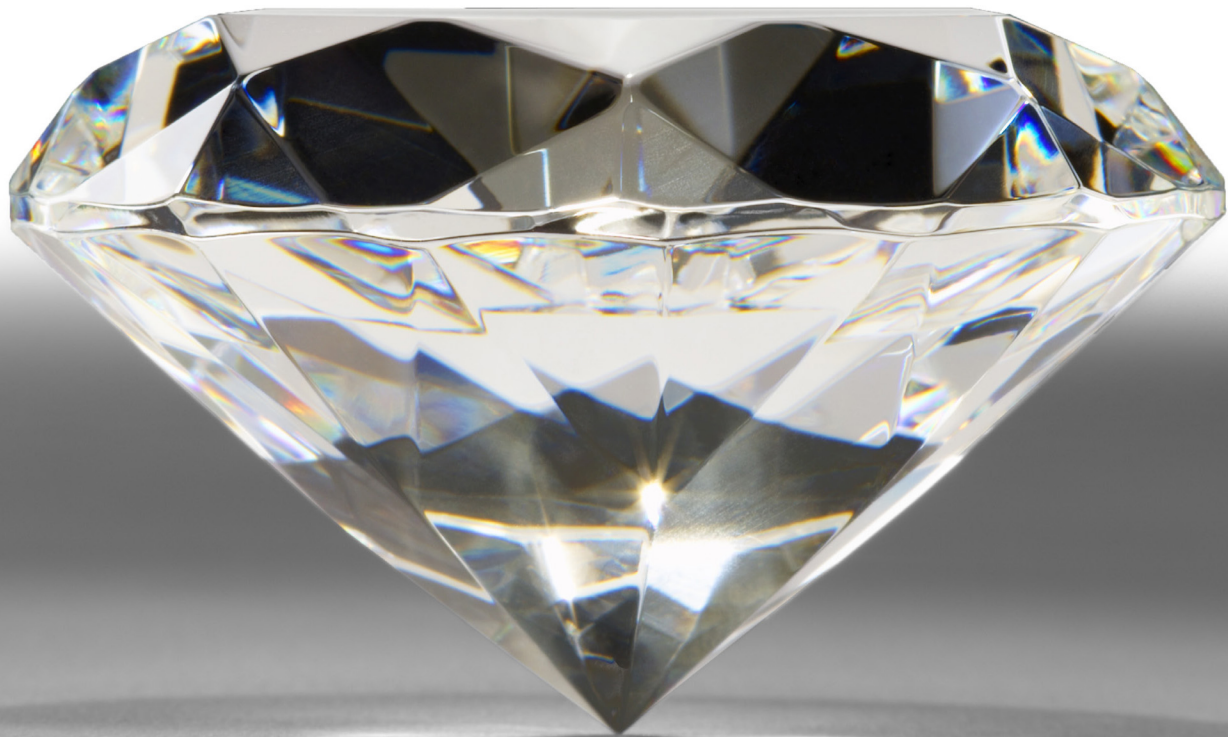
*Third Edition*

William Navidi

*Colorado School of Mines*

Barry Monk

*Macon State College*



**Mc  
Graw  
Hill**  
Education

# Elementary **STATISTICS**

*Third Edition*

**William Navidi**

*Colorado School of Mines*

**Barry Monk**

*Middle Georgia State University*



**Mc  
Graw  
Hill**  
Education



## ELEMENTARY STATISTICS, THIRD EDITION

Published by McGraw-Hill Education, 2 Penn Plaza, New York, NY 10121. Copyright© 2019 by McGraw-Hill Education. All rights reserved. Printed in the United States of America. Previous editions © 2016 and 2013. No part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written consent of McGraw-Hill Education, including, but not limited to, in any network or other electronic storage or transmission, or broadcast for distance learning.

Some ancillaries, including electronic and print components, may not be available to customers outside the United States.

This book is printed on acid-free paper.

1 2 3 4 5 6 7 8 9 LWI 22 21 20 19 18

ISBN: 978-1-259-96945-4 (Student Bound Edition)  
MHID: 1-259-96945-2

ISBN: 978-1-260-37373-8 (Annotated Instructor's Edition)  
MHID: 1-260-37373-8

ISBN: 978-1-260-37352-3 (Loose Leaf Edition)  
MHID: 1-260-37352-5

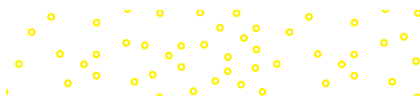
Portfolio Manager: *Chrissy Skogen*  
Product Developer: *Nora Devlin*  
Marketing Manager: *Alison Frederick*  
Content Project Manager: *Peggy J. Selle*  
Buyer: *Laura Fuller*  
Design: *Matt Backhaus*  
Content Licensing Specialist: *Lorraine Buczek*  
Cover image/frontmatter design element: ©*Don Farrall/Getty Images*  
Compositor: *SPi Global*

All credits appearing on page or at the end of the book are considered to be an extension of the copyright page.

### Library of Congress Cataloging-in-Publication Data

Names: Navidi, William Cyrus, author. | Monk, Barry (Barry J.) author.  
Title: Elementary statistics / William Navidi, Colorado School of Mines,  
Barry Monk, Middle Georgia State College.  
Description: Third edition. | New York, NY : McGraw-Hill Education, [2019] | Includes index.  
Identifiers: LCCN 2017022827 | ISBN 9781259969454 (alk. paper)  
Subjects: LCSH: Mathematical statistics—Textbooks.  
Classification: LCC QA276.12 .N385 2019 | DDC 519.5—dc23 LC record available at <https://lcn.loc.gov/2017022827>

The Internet addresses listed in the text were accurate at the time of publication. The inclusion of a website does not indicate an endorsement by the authors or McGraw-Hill Education, and McGraw-Hill Education does not guarantee the accuracy of the information presented at these sites.



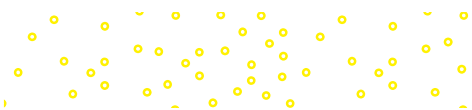


To Catherine, Sarah, and Thomas

—*William Navidi*

To Shaun, Dawn, and Ben

—*Barry Monk*





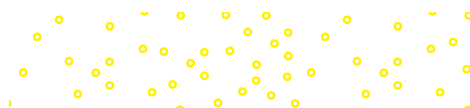
# About the Authors



**William Navidi** is a professor of Applied Mathematics and Statistics at the Colorado School of Mines in Golden, Colorado. He received a Bachelor's degree in Mathematics from New College, a Master's degree in Mathematics from Michigan State University, and a Ph.D. in Statistics from the University of California at Berkeley. Bill began his teaching career at the County College of Morris, a two-year college in Dover, New Jersey. He has taught mathematics and statistics at all levels, from developmental through the graduate level. Bill has written two Engineering Statistics textbooks for McGraw-Hill. In his spare time, he likes to play racquetball.

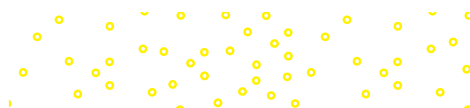


**Barry Monk** is a Professor of Mathematics at Middle Georgia State University in Macon, Georgia. Barry received a Bachelor of Science in Mathematical Statistics, a Master of Arts in Mathematics specializing in Optimization and Statistics, and a Ph.D. in Applied Mathematics, all from the University of Alabama. Barry has been teaching Introductory Statistics since 1992 in the classroom and online environments. Barry has a minor in Creative Writing and is a skilled jazz pianist.





CHAPTER	<b>1</b>	Basic Ideas	1
CHAPTER	<b>2</b>	Graphical Summaries of Data	35
CHAPTER	<b>3</b>	Numerical Summaries of Data	93
CHAPTER	<b>4</b>	Summarizing Bivariate Data	157
CHAPTER	<b>5</b>	Probability	203
CHAPTER	<b>6</b>	Discrete Probability Distributions	253
CHAPTER	<b>7</b>	The Normal Distribution	293
CHAPTER	<b>8</b>	Confidence Intervals	357
CHAPTER	<b>9</b>	Hypothesis Testing	415
CHAPTER	<b>10</b>	Two-Sample Confidence Intervals	487
CHAPTER	<b>11</b>	Two-Sample Hypothesis Tests	521
CHAPTER	<b>12</b>	Tests with Qualitative Data	569
CHAPTER	<b>13</b>	Inference in Linear Models	595
CHAPTER	<b>14</b>	Analysis of Variance	643
CHAPTER	<b>15</b>	Nonparametric Statistics	679







Preface xi  
Acknowledgments xiii  
Index of Applications xxiv

## CHAPTER 1 Basic Ideas 1



©Tatiana Grozetskaya/Shutterstock

**1.1** Sampling 2  
**1.2** Types of Data 12  
**1.3** Design of Experiments 18  
**1.4** Bias in Studies 26  
Chapter 1 Summary 30  
Vocabulary and Notation 30  
Chapter Quiz 31  
Review Exercises 31

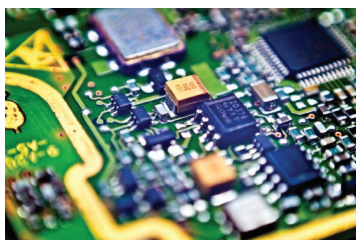
## CHAPTER 2 Graphical Summaries of Data 35



©MikeFlippo/123RF

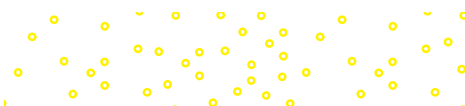
**2.1** Graphical Summaries for Qualitative Data 36  
**2.2** Frequency Distributions and Their Graphs 49  
**2.3** More Graphs for Quantitative Data 68  
**2.4** Graphs Can Be Misleading 80  
Chapter 2 Summary 87  
Vocabulary and Notation 87  
Chapter Quiz 87  
Review Exercises 88

## CHAPTER 3 Numerical Summaries of Data 93



©adistock/123RF

**3.1** Measures of Center 94  
**3.2** Measures of Spread 113  
**3.3** Measures of Position 133  
Chapter 3 Summary 151  
Vocabulary and Notation 151  
Chapter Quiz 152  
Review Exercises 153



## CHAPTER 4 Summarizing Bivariate Data 157



©Stockbyte/Punchstock RF

- 4.1** Correlation 158
  - 4.2** The Least-Squares Regression Line 170
  - 4.3** Features and Limitations of the Least-Squares Regression Line 182
- Chapter 4 Summary 195  
Vocabulary and Notation 196  
Chapter Quiz 196  
Review Exercises 197

## CHAPTER 5 Probability 203



©Ryan McVay/Getty Images

- 5.1** Basic Concepts of Probability 204
  - 5.2** The Addition Rule and the Rule of Complements 216
  - 5.3** Conditional Probability and the Multiplication Rule 225
  - 5.4** Counting 238
- Chapter 5 Summary 247  
Vocabulary and Notation 247  
Chapter Quiz 248  
Review Exercises 249

## CHAPTER 6 Discrete Probability Distributions 253



©Andriy Popov/123RF

- 6.1** Random Variables 254
  - 6.2** The Binomial Distribution 268
  - 6.3** The Poisson Distribution 279
- Chapter 6 Summary 286  
Vocabulary and Notation 286  
Chapter Quiz 286  
Review Exercises 287

## CHAPTER 7 The Normal Distribution 293



©Getty RF

- 7.1** The Standard Normal Curve 294
  - 7.2** Applications of the Normal Distribution 308
  - 7.3** Sampling Distributions and the Central Limit Theorem 319
  - 7.4** The Central Limit Theorem for Proportions 328
  - 7.5** The Normal Approximation to the Binomial Distribution 334
  - 7.6** Assessing Normality 341
- Chapter 7 Summary 351  
Vocabulary and Notation 352  
Chapter Quiz 352  
Review Exercises 353







©Schroptschop/Getty Images

- 8.1** Confidence Intervals for a Population Mean, Standard Deviation Known 358
- 8.2** Confidence Intervals for a Population Mean, Standard Deviation Unknown 376
- 8.3** Confidence Intervals for a Population Proportion 389
- 8.4** Confidence Intervals for a Standard Deviation 401
- 8.5** Determining Which Method to Use 406
- Chapter 8 Summary 409
- Vocabulary and Notation 410
- Chapter Quiz 410
- Review Exercises 411



©Corbis RF/Getty Images

- 9.1** Basic Principles of Hypothesis Testing 416
- 9.2** Hypothesis Tests for a Population Mean, Standard Deviation Known 421
- 9.3** Hypothesis Tests for a Population Mean, Standard Deviation Unknown 445
- 9.4** Hypothesis Tests for Proportions 459
- 9.5** Hypothesis Tests for a Standard Deviation 470
- 9.6** Determining Which Method to Use 473
- 9.7** Power 476
- Chapter 9 Summary 480
- Vocabulary and Notation 481
- Chapter Quiz 481
- Review Exercises 482



©Ridofranz/Getty Images

- 10.1** Confidence Intervals for the Difference Between Two Means: Independent Samples 488
- 10.2** Confidence Intervals for the Difference Between Two Proportions 499
- 10.3** Confidence Intervals for the Difference Between Two Means: Paired Samples 507
- Chapter 10 Summary 515
- Vocabulary and Notation 515
- Chapter Quiz 515
- Review Exercises 516



## CHAPTER 11 Two-Sample Hypothesis Tests 521



©Corbis RF/Getty Images

- 11.1** Hypothesis Tests for the Difference Between Two Means: Independent Samples 522
  - 11.2** Hypothesis Tests for the Difference Between Two Proportions 533
  - 11.3** Hypothesis Tests for the Difference Between Two Means: Paired Samples 544
  - 11.4** Hypothesis Tests for Two Population Standard Deviations 553
  - 11.5** The Multiple Testing Problem 559
- Chapter 11 Summary 563  
Vocabulary and Notation 563  
Chapter Quiz 563  
Review Exercises 564

## CHAPTER 12 Tests with Qualitative Data 569



©Getty RF

- 12.1** Testing Goodness of Fit 570
  - 12.2** Tests for Independence and Homogeneity 579
- Chapter 12 Summary 589  
Vocabulary and Notation 589  
Chapter Quiz 589  
Review Exercises 590

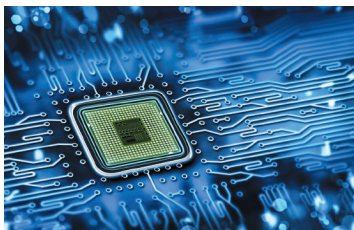
## CHAPTER 13 Inference in Linear Models 595



©Vincent Ting/Getty Images

- 13.1** Inference on the Slope of the Regression Line 596
  - 13.2** Inference About the Response 611
  - 13.3** Multiple Regression 618
- Chapter 13 Summary 634  
Vocabulary and Notation 635  
Chapter Quiz 635  
Review Exercises 636

## CHAPTER 14 Analysis of Variance 643



©crstrbrt/123RF

- 14.1** One-Way Analysis of Variance 644
  - 14.2** Two-Way Analysis of Variance 660
- Chapter 14 Summary 673  
Vocabulary and Notation 673  
Chapter Quiz 674  
Review Exercises 675



## CHAPTER 15 Nonparametric Statistics 679

---



©iStock/Getty Images

**15.1** The Sign Test 680

**15.2** The Rank-Sum Test 685

**15.3** The Signed-Rank Test 691

Chapter 15 Summary 696

Vocabulary and Notation 696

Chapter Quiz 697

Review Exercises 697

Appendix A Tables A-1

Appendix B TI-84 PLUS Stat Wizards B-1

Answers to Odd-Numbered Exercises (Student edition only) SA-1

Answers to Selected Exercises (Instructor's edition only) IA-1

Index I-1





This book is designed for an introductory course in statistics. The mathematical prerequisite is basic algebra. In addition to presenting the mechanics of the subject, we have endeavored to explain the concepts behind them, in a writing style as straightforward, clear, and engaging as we could make it. As practicing statisticians, we have done everything possible to ensure that the material presented is accurate and correct. We believe that this book will enable instructors to explore statistical concepts in depth yet remain easy for students to read and understand.

To achieve this goal, we have incorporated a number of useful pedagogical features:

## Features

- **Check Your Understanding Exercises:** After each concept is explained, one or more exercises are immediately provided for students to be sure they are following the material. These exercises provide students with confidence that they are ready to go on, or alert them to the need to review the material just covered.
- **Explain It Again:** Many important concepts are reinforced with additional explanation in these marginal notes.
- **Real Data:** Statistics instructors universally agree that the use of real data engages students and convinces them of the usefulness of the subject. A great many of the examples and exercises use real data. Some data sets explore topics in health or social sciences, while others are based in popular culture such as movies, contemporary music, or video games.
- **Integration of Technology:** Many examples contain screenshots from the TI-84 Plus calculator, MINITAB, and Excel. Each section contains detailed, step-by-step instructions, where applicable, explaining how to use these forms of technology to carry out the procedures explained in the text.
- **Interpreting Technology:** Many exercises present output from technology and require the student to interpret the results.
- **Write About It:** These exercises, found at the end of each chapter, require students to explain statistical concepts in their own words.
- **Case Studies:** Each chapter begins with a discussion of a real problem. At the end of the chapter, a case study demonstrates applications of chapter concepts to the problem.

## Flexibility

We have endeavored to make our book flexible enough to work effectively with a wide variety of instructor styles and preferences. We cover both the  $P$ -value and critical value approaches to hypothesis testing, so instructors can choose to cover either or both of these methods. The material on two-sample inference is divided into two chapters—Chapter 10 on two-sample confidence intervals, and Chapter 11 on two-sample hypothesis tests. This gives instructors the option of covering all the material on confidence intervals before starting hypothesis testing, by covering Chapter 10 immediately after Chapter 8.

We have placed the material on descriptive statistics for bivariate data immediately following descriptive statistics for univariate data. Those who wish to cover bivariate description and inference together may postpone Chapter 4 until sometime before covering Chapter 13.

Instructors differ widely in their preferences regarding the depth of coverage of probability. A light treatment of the subject may be obtained by covering Section 5.1 and skipping the rest of the chapter. More depth can be obtained by covering Sections 5.2 and 5.3. Section 5.4 on counting can be included for an even more comprehensive treatment.

## Supplements

Supplements, including online homework, videos, guided student notes, and PowerPoint presentations, play an increasingly important role in the educational process. As authors, we have adopted a hands-on approach to the development of our supplements, to make sure that they are consistent with the style of the text and that they work effectively with a variety of instructor preferences. In particular, our online homework package offers instructors the flexibility to choose whether the solutions that students view are based on tables or technology, where applicable.



# New in This Edition

---

The third edition of the book is intended to extend the strengths of the second. Some of the changes are:

- A new objective on the weighted mean has been added.
- A large number of new exercises have been included, many of which involve real data from recent sources.
- Many new conceptual exercises have been added, for example, about detecting confounding in public health studies, drawing inferences from the shape of a histogram, interpreting technology output to detect outliers, reinforcing the concept that the Central Limit Theorem applies to the sample mean rather than individual sample items, and understanding the effect of sample size on the margin of error of a confidence interval.
- A new supplement to accompany the text has been developed that focuses on prerequisite skills.
- Several of the case studies have been updated.
- The exposition has been improved in a number of places.

*William Navidi*

*Barry Monk*



We are indebted to many people for contributions at every stage of development. Colleagues and students who reviewed the evolving manuscript provided many valuable suggestions. In particular, John Trimboli, Don Brown, and Duane Day contributed to the supplements, and Mary Wolfe helped create the video presentations. Ashlyn Munson contributed a number of exercises, and Tim Chappell played an important role in the development of our digital content.

The staff at McGraw-Hill has been extremely capable and supportive. Project Manager Peggy Selle was always patient and helpful. Cynthia Northrup was superb in directing the development of our digital content. We owe a debt of thanks to Alison Frederick for her creative marketing and diligence in spreading the word about our book. We appreciate the guidance of our editors, Nora Devlin, Chrissy Skogen and Christina Sanders, whose input has considerably improved the final product.

*William Navidi  
Barry Monk*

## Feedback from Statistics Instructors

Paramount to the development of *Elementary Statistics* was the invaluable feedback provided by the instructors from around the country who reviewed the manuscript while it was in development.

## A Special Thanks to All of the Symposia and Focus Group Attendees

James Adair, *Dyersburg State Community College*  
Andrea Adlman, *Ventura College*  
Leandro Alvarez, *Miami Dade College*  
Simon Aman, *City Colleges of Chicago*  
Diane Benner, *Harrisburg Area Community College*  
Karen Brady, *Columbus State Community College*  
Liliana Brand, *Northern Essex Community College*  
Denise Brown, *Collin College-Spring Creek*  
Don Brown, *Middle Georgia State University*  
Mary Brown, *Harrisburg Area Community College*  
Gerald Busald, *San Antonio College*  
Anna Butler, *Polk State College*  
Robert Cappetta, *College of DuPage*  
Joe Castillo, *Broward College*  
Michele Catterton, *Harford Community College*  
Tim Chappell, *Metropolitan Community College - Penn Valley*  
Ivette Chuca, *El Paso Community College*  
James Condor, *State College of Florida*  
Milena Cuellar, *LaGuardia Community College*  
Phyllis Curtiss, *Grand Valley State University*  
Hema Deshmukh, *Mercyhurst University*  
Mitra Devkota, *Shawnee State University*  
Sue Jones Dobbyn, *Pellissippi State Community College*

Rob Eby, *Blinn College-Bryan Campus*  
Charles Wayne Ehler, *Anne Arundel Community College*  
Franco Fedele, *University of West Florida*  
Robert Fusco, *Broward College*  
Wojciech Golik, *Lindenwood University*  
Tim Grant, *Southwestern Illinois College*  
Todd Hendricks, *Georgia State University, Perimeter College*  
Mary Hill, *College of DuPage*  
Steward Huang, *University of Arkansas-Fort Smith*  
Vera Hu-Hyneman, *Suffolk County Community College*  
Laura Iossi, *Broward College*  
Brittany Juraszek, *Santa Fe College*  
Maryann Justinger, *Erie Community College-South Campus*  
Joseph Karnowski, *Norwalk Community College*  
Esmarie Kennedy, *San Antonio College*  
Lynette Kenyon, *Collin College-Plano*  
Raja Khoury, *Collin College-Plano*  
Alexander Kolesnik, *Ventura College*  
Holly Kresch, *Diablo Valley College*  
JoAnn Kump, *West Chester University*  
Dan Kumpf, *Ventura College*  
Erica Kwiatkowski-Egizio, *Joliet Junior College*



Pam Lowry, *Bellevue College*  
Corey Manchester, *Grossmont College*  
Scott McDaniel, *Middle Tennessee State University*  
Mikal McDowell, *Cedar Valley College*  
Ryan Melendez, *Arizona State University*  
Lynette Meslinsky, *Erie Community College*  
Penny Morris, *Polk State College*  
Brittany Mosby, *Pellissippi State Community College*  
Cindy Moss, *Skyline College*  
Kris Mudunuri, *Long Beach City College*  
Linda Myers, *Harrisburg Area Community College*  
Sean Nguyen, *San Francisco State University*  
Ronald Palcic, *Johnson County Community College*  
Matthew Prugel, *Harrisburg Area Community College*  
Blanche Presley, *Middle Georgia State University*  
Ahmed Rashed, *Richland College*  
Cyndi Roemer, *Union County College*  
Ginger Rowell, *Middle Tennessee State University*  
Sudipta Roy, *Kanakee Community College*  
Ligo Samuel, *Austin Peay State University*  
Jamal Salahat, *Owens State Community College*  
Kathy Shay, *Middlesex County College*  
Laura Shick, *Clemson University*  
Larry Shrewsbury, *Southern Oregon University*  
Shannon Solis, *San Jacinto College-North*  
Tommy Thompson, *Cedar Valley College*  
John Trimboli, *Middle Georgia State University*  
Rita Sowell, *Volunteer State Community College*  
Chris Turner, *Pensacola State College*  
Jo Tucker, *Tarrant County College*  
Dave Vinson, *Pellissippi State Community College*  
Henry Wakhungu, *Indiana University*  
Bin Wang, *University of South Alabama*  
Daniel Wang, *Central Michigan University*  
Jennifer Zeigenfuse, *Anne Arundel Community College*

Gregory Bloxom, *Pensacola State College*  
Gabi Booth, *Daytona State College*  
Dale Bowman, *University of Memphis*  
Brian Bradie, *Christopher Newport University*  
Tonia Broome, *Gaston College*  
Donna Brouillette, *Georgia State University, Perimeter College*  
Allen Brown, *Wabash Valley College*  
Denise Brown, *Collin Community College*  
Don Brown, *Middle Georgia State University*  
Mary Brown, *Harrisburg Area Community College*  
Jennifer Bryan, *Oklahoma Christian University*  
William Burgin, *Gaston College*  
Gerald Busald, *San Antonio College*  
David Busekist, *Southeastern Louisiana University*  
Lynn Cade, *Pensacola State College*  
Elizabeth Carrico, *Illinois Central College*  
Connie Carroll, *Guilford Technical Community College*  
Joseph Castillo, *Broward College*  
Linda Chan, *Mount San Antonio College & Pasadena City College*  
Ayona Chatterjee, *University of West Georgia*  
Chand Chauhan, *Indiana University Purdue University Fort Wayne*  
Pinyuen Chen, *Syracuse University*  
Askar Choudhury, *Illinois State University*  
Lee Clendenning, *University of North Georgia*  
James Condor, *State College of Florida-Manatee*  
Natalie Creed, *Gaston College*  
John Curran, *Eastern Michigan University*  
John Daniels, *Central Michigan University*  
Shibasish Dasgupta, *University of South Alabama*  
Nataliya Doroshenko, *University of Memphis*  
Brandon Doughery, *Montgomery County Community College*  
Larry Dumais, *American River College*  
Christina Dwyer, *State College of Florida-Manatee*  
Wayne Ehler, *Anne Arundel Community College*  
Mark Ellis, *Central Piedmont Community College*  
Dr. Angela Everett, *Chattanooga State Community College*  
Franco Fedele, *University of West Florida*  
Harshini Fernando, *Purdue University—North Central*  
Art Fortgang, *Southern Oregon University*  
Thomas Fox, *Cleveland State Community College*  
Marnie Francisco, *Foothill College*  
Robert Fusco, *Broward College*  
Linda Galloway, *Kennesaw State University*  
David Garth, *Truman State University*  
Sharon Giles, *Grossmont Community College*  
Mary Elizabeth Gore, *Community College of Baltimore County*  
Carrie Grant, *Flagler College*  
Delbert Greear, *University of North Georgia*

## Manuscript Review Panels

Alisher Abdullayev, *American River College*  
Andrea Adlman, *Ventura College*  
Olcay Akman, *Illinois State University*  
Raid Amin, *University of West Florida*  
Wesley L. Anderson, *Northwest Vista College*  
Peter Arvanites, *Rockland Community College*  
Diana Asmus, *Greenville Technical College*  
John Avioli, *Christopher Newport University*  
Heather A. Barker, *Elon University*  
Robert Bass, *Gardner-Webb University*  
Robbin Bates-Yelverton, *Park University*  
Lynn Beckett-Lemus, *El Camino College*  
Diane Benner, *Harrisburg Area Community College*  
Abraham Biggs, *Broward College*  
Wes Black, *Illinois Valley Community College*

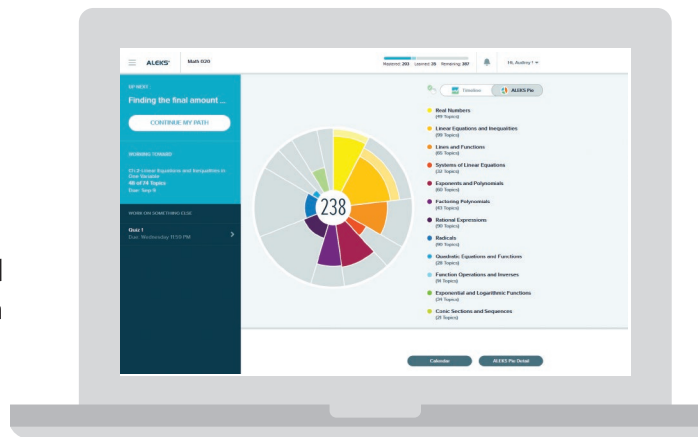
Jason Greshman, *Nova Southeastern University*  
 David Gurney, *Southeastern Louisiana University*  
 Chris Hail, *Union University-Jackson*  
 Ryan Harper, *Spartanburg Community College*  
 Phillip Harris, *Illinois Central College*  
 James Harrington, *Adirondack Community College*  
 Matthew He, *Nova Southeastern University*  
 Mary Beth Headlee, *State College of Florida-Manatee*  
 James Helmreich, *Marist College*  
 Todd A. Hendricks, *Perimeter Georgia State University, College*  
 Jada Hill, *Richland College*  
 Mary Hill, *College of DuPage*  
 William Huepenbecker, *Bowling Green State University-Firelands*  
 Jenny Hughes, *Columbia Basin College*  
 Patricia Humphrey, *Georgia Southern University*  
 Nancy Johnson, *State College of Florida-Manatee*  
 Maryann Justinger, *Erie Community College-South Campus*  
 Joseph Karnowski, *Norwalk Community College*  
 Susitha Karunaratne, *Purdue University—North Central*  
 Dr. Ryan H. Kasha, Ph.D., *Valencia College*  
 Joseph Kazimir, *East Los Angeles College*  
 Esmarie Kennedy, *San Antonio College*  
 Lynette Kenyon, *Collin College*  
 Gary Kersting, *North Central Michigan College*  
 Raja Khoury, *Collin College*  
 Heidi Kiley, *Suffolk County Community College-Selden*  
 Daniel Kim, *Southern Oregon University*  
 Ann Kirkpatrick, *Southeastern Louisiana University*  
 John Klages, *County College of Morris*  
 Karon Klipple, *San Diego City College*  
 Matthew Knowlen, *Horry Georgetown Tech College*  
 JoAnn Kump, *West Chester University*  
 Alex Kolesnik, *Ventura College*  
 Bohdan Kunciw, *Salisbury University*  
 Erica Kwiatkowski-Egizio, *Joliet Junior College*  
 William Langston, *Finger Lakes Community College*  
 Tracy Leshan, *Baltimore City Community College*  
 Nicole Lewis, *East Tennessee State University*  
 Jiawei Liu, *Georgia State University*  
 Fujia Lu, *Endicott College*  
 Habid Maagoul, *Northern Essex Community College*  
 Timothy Maharry, *Northwestern Oklahoma State University*  
 Aldo Maldonado, *Park University*  
 Kenneth Mann, *Catawba Valley Community College*  
 James Martin, *Christopher Newport University*  
 Erin Martin-Wilding, *Parkland College*  
 Amina Mathias, *Cecil College*  
 Catherine Matos, *Clayton State University*  
 Angie Matthews, *Broward College*  
 Mark McFadden, *Montgomery County Community College*  
 Karen McKarnin, *Allen Community College*  
 Penny Morris, *Polk Community College*  
 B. K. Mudunuri, *Long Beach City College-CalPoly Pomona*  
 Linda Myers, *Harrisburg Area Community College*  
 Miroslaw Mystkowski, *Gardner-Webb University*  
 Shai Neumann, *Brevard Community College*  
 Francis Kyei Nkansah, *Bunker Hill Community College*  
 Karen Orr, *Roane State Community College*  
 Richard Owens, *Park University*  
 Irene Palacios, *Grossmont College*  
 Luca Petrelli, *Mount Saint Mary's University*  
 Blanche Presley, *Middle Georgia State University*  
 Robert Prince, *Berry College*  
 Richard Puscas, *Georgia State University, Perimeter College*  
 Ramaswamy Radhakrishnan, *Illinois State University*  
 Leela Rakesh, *Central Michigan University*  
 Gina Reed, *University of North Georgia*  
 Andrea Reese, *Daytona State College-Daytona Beach*  
 Jim Robison-Cox, *Montana State University*  
 Alex Rolon, *Northampton Community College*  
 Jason Rosenberry, *Harrisburg Area Community College*  
 Yolanda Rush, *Illinois Central College*  
 Loula Rytikova, *George Mason University*  
 Fary Sami, *Harford Community College*  
 O. Dale Saylor, *University of South Carolina Upstate*  
 Vicki Schell, *Pensacola State College*  
 Angela Schirck, *Broward College*  
 Carol Schoen, *University of Wisconsin-Eau Claire*  
 Pali Sen, *University of North Florida*  
 Rosa Seyfried, *Harrisburg Area Community College*  
 Larry Shrewsbury, *Southern Oregon University*  
 Abdallah Shuaibi, *Truman College*  
 Rick Silvey, *University of Saint Mary*  
 Russell Simmons, *Brookhaven College*  
 Peggy Slavik, *University of Saint Mary*  
 Karen Smith, *University of West Georgia*  
 Aileen Solomon, *Trident Technical College*  
 Pam Stogsdill, *Bossier Parish Community College*  
 Susan Surina, *George Mason University*  
 Victor Swaim, *Southeastern Louisiana University*  
 Scott Sykes, *University of West Georgia*  
 Van Tran, *San Francisco State University*  
 John Trimboli, *Middle Georgia State University*  
 Barbara Tucker, *Tarrant County College South East*  
 Steven Forbes Tuckey, *Jackson Community College*  
 Christopher Turner, *Pensacola State College*  
 Anke Van Zuylen, *College of William and Mary*  
 Dave Vinson, *Pellissippi State Community College*  
 Erwin Walker, *Clemson University*

Joseph Walker, *Georgia State University*  
James Wan, *Long Beach City College*  
Xiaohong Wang, *Central Michigan University*  
Jason Willis, *Gardner-Webb University*  
Fuzhen Zhang, *Nova Southeastern University*

Yichuan Zhao, *Georgia State University*  
Deborah Ziegler, *Hannibal LaGrange University*  
Bashar Zogheib, *Nova Southeastern University*  
Stephanie Zwyghuizen, *Jamestown Community College*

## Looking to motivate and engage students? Problem solved!

ALEKS® uses artificial intelligence to precisely map what each student knows, doesn't know, and is most ready to learn in a given course area. The system interacts with each student like a skilled human tutor, delivering a cycle of highly individualized learning and assessment that ensures mastery. Students are shown an optimal path to success, and instructors have the analytics they need to deliver a data-informed, impactful learning experience.



**"ALEKS has helped to create the best classroom experience I've had in 36 years. I can reach each student with ALEKS."**  
*– Tommy Thompson, Cedar Valley College, TX*

## How can ALEKS help solve your students' challenges?

### I did all my homework, so why am I failing my exams?

The purpose of homework is to ensure mastery and prepare students for exams. ALEKS is the only adaptive learning system that ensures mastery through periodic assessments and delivers just-in-time remediation to efficiently prepare students. Because of how ALEKS presents lessons and practice, students learn by understanding the core principle of a concept rather than just memorizing a process.

### I'm too far behind to catch up. - OR - I've already done this, I'm bored.

No two students are alike. So why start everyone on the same page? ALEKS diagnoses what each student knows and doesn't know, and prescribes an optimized learning path through your curriculum. Students only work on topics they are ready to learn, and they have a proven learning success rate of 93% or higher. As students watch their progress in the ALEKS Pie grow, their confidence grows with it.

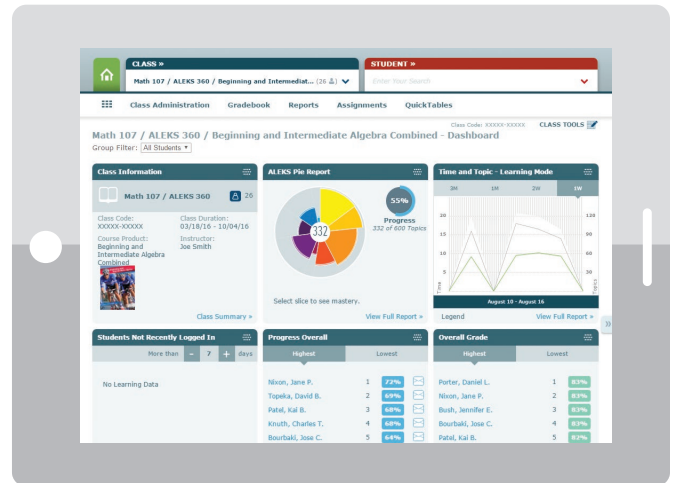
I need something that solves the problem of cost, time to completion, and student preparedness.

ALEKS is the perfect solution to these common problems. It provides an efficient path to mastery through its individualized cycle of learning and assessment. Students move through the course content more efficiently and are better prepared for subsequent courses. This saves both the institution and the student money. Increased student success means more students graduate.

My administration and department measure success differently. How can we compare notes?

ALEKS offers the most comprehensive and detailed data analytics on the market. From helping the student in the back row to monitoring pass rates across the department and institution, ALEKS delivers the data needed at all levels.

The customizable and intuitive reporting features allow you and your colleagues to easily gather, interpret, and share the data you need, when you need it.



The ALEKS Instructor Module offers a modern, intuitive interface to manage courses and track student progress.

## Trusted Service and Support

A unique solution requires unique support. A dedicated team of specialists and faculty consultants ensure that your ALEKS implementation is seamless and painless . . . from start to finish.

### ALEKS Service and Support Offers:

- LMS integration that provides single sign-on capability and gradebook synchronization
- Industry-leading technical support and 99.97% uptime
- Flexible courses that can align with any textbook and/or resources, for any classroom model
- Resources for implementation, first day of class orientation, how-to videos and more
- Onsite seminars/workshops and webinars with McGraw-Hill and faculty consultants



## Looking for a consistent voice between text and digital? Problem solved!

McGraw-Hill Connect<sup>®</sup> Math Hosted by ALEKS<sup>®</sup> offers everything students and instructors need in one intuitive platform. ConnectMath is an online homework engine where the problems and solutions are consistent with the textbook authors' approach. It also offers integration with SmartBook, an assignable, adaptive eBook and study tool that directs students to the content they don't know and helps them study more efficiently. With ConnectMath, you get the tools you need to be the teacher you want to be.



©Steve Debenport/Getty Images

"I like that ConnectMath reaches students with different learning styles . . . our students are engaged, attend class, and ask excellent questions."  
– Kelly Davis, South Texas College

## Trusted Service and Support

A dedicated team of specialists and faculty consultants ensure that your ConnectMath implementation is seamless and painless . . . from start to finish.

### ConnectMath Service and Support Offers:

- LMS integration that provides single sign-on capability and gradebook synchronization
- Industry-leading technical support and 99.97% uptime
- Resources for implementation, first day of class orientation, how-to videos and more
- Onsite seminars/workshops and webinars with McGraw-Hill and faculty consultants



I like to learn by \_\_\_\_\_.

Whether it's reading, watching, discovering, or doing, ConnectMath has something for everyone. Instructors can create assignments that accommodate different learning styles, and students aren't stuck with boring multiple-choice problems. Instead they have a myriad of motivational learning and media resources at their fingertips. SmartBook delivers an interactive reading and learning experience that provides personalized guidance and just-in-time remediation. This helps students to focus on what they need, right when they need it.

I still don't get it. Can you do that problem again?

Because the content in ConnectMath is author-developed and goes through a rigorous quality control process, students hear one voice, one style, and don't get lost moving from text to digital. The high-quality, author-developed videos provide students ample opportunities to master concepts and practice skills that they need extra help with . . . all of which are integrated in the ConnectMath platform and the eBook.

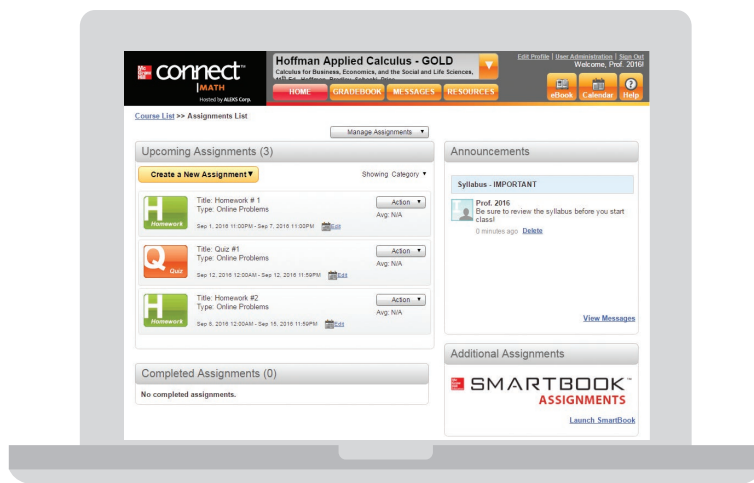
## How can ConnectMath help solve your classroom challenges?

I need meaningful data to measure student success!

From helping the student in the back row to tracking learning trends for your entire course, ConnectMath delivers the data you need to make an impactful, meaningful learning experience for students. With easy-to-interpret, downloadable reports, you can analyze learning rates for each assignment, monitor time on task, and learn where students' strengths and weaknesses are in each course area.

We're going with the \_\_\_\_\_ (flipped classroom, corequisite model, etc.) implementation.

ConnectMath can be used in any course setup. Each course in ConnectMath comes complete with its own set of text-specific assignments, author-developed videos and learning resources, and an integrated eBook that cater to the needs of your specific course. The easy-to-navigate home page keeps the learning curve at a minimum, but we still offer an abundance of tutorials and videos to help get you and your colleagues started.





## ALEKS® PREP

Students unprepared for your course? Do they lack critical prerequisite skills to succeed? Problem Solved!

ALEKS Prep courses use artificial intelligence to target students' prerequisite knowledge gaps and provide individualized learning and remediation to ensure students have the skills to succeed in their statistics course. With ALEKS, students are more successful on exams and instructors save valuable time both in the class and during office hours.



## SMARTBOOK® SmartBook™

SmartBook™ is the first and only adaptive reading experience available for the higher education market. Powered by the intelligent and adaptive LearnSmart engine, SmartBook facilitates the reading process by identifying what content a student knows and doesn't know. As a student reads, the material continuously adapts to ensure the student is focused on the content he or she needs the most to close specific knowledge gaps.



## create®

With McGraw-Hill Create™, you can easily rearrange chapters, combine material from other content sources, and quickly upload content you have written like your course syllabus or teaching notes. Find the content you need in Create by searching through thousands of leading McGraw-Hill textbooks. Arrange your book to fit your teaching style. Create even allows you to personalize your book's appearance by selecting the cover and adding your name, school, and course information. Assemble a Create book and you'll receive a complimentary print review copy in 3–5 business days or a complimentary electronic review copy (eComp) via email in minutes. Go to [www.mcgrawhillcreate.com](http://www.mcgrawhillcreate.com) today and experience how McGraw-Hill Create™ empowers you to teach *your* students *your* way.

## Videos

Author-produced lecture videos introduce concepts, definitions, formulas, and problem-solving procedures to help students better comprehend the topic at hand. Exercise videos illustrate the authors working through selected exercises, following the solution methodology employed in the text. These videos are closed-captioned for the hearing-impaired, and meet the Americans with Disabilities Act Standards for Accessible Design.

## Computerized Test Bank Online (instructors only)

This computerized test bank, available online to adopting instructors, utilizes TestGen® cross-platform test generation software to quickly and easily create customized exams. Using hundreds of test items taken directly from the text, TestGen allows rapid test creation and flexibility for instructors to create their own questions from scratch with ability to randomize number values. Powerful search and sort functions help quickly locate questions and arrange them in any order, and built-in mathematical templates let instructors insert stylized text, symbols, graphics, and equations directly into questions without need for a separate equation editor.

## MegaStat®

MegaStat® is a statistical add-in for Microsoft Excel, handcrafted by J. B. Orris of Butler University. When MegaStat is installed, it appears as a menu item on the Excel menu bar and allows you to perform statistical analysis on data in an Excel workbook.

## Instructor's Solutions Manual

Derived from author-approved Connect solutions, this manual contains detailed solutions to all of the problems in the text.

## **TI-84 Plus Graphing Calculator Manual**

This friendly, author-influenced manual teaches students to learn about statistics and solve problems by using this calculator while following each text chapter.

## **Excel Manual**

This workbook, specially designed to accompany the text by the authors, provides additional practice in applying the chapter concepts while using Excel.

## **MINITAB 17 Manual**

With guidance from the authors, this manual includes material from the book to provide seamless use from one to the other, providing additional practice in applying the chapter concepts while using the MINITAB program.

## **Guided Student Notes**

Guided notes provide instructors with the framework of day-by-day class activities for each section in the book. Each lecture guide can help instructors make more efficient use of class time and can help keep students focused on active learning. Students who use the lecture guides have the framework of well-organized notes that can be completed with the instructor in class.

## **Data Sets**

Data sets from selected exercises have been pre-populated into MINITAB, TI-Graph Link, Excel, SPSS, and comma-delimited ASCII formats for student and instructor use. These files are available on the text's website.

## **Print Supplements**

### **Annotated Instructor's Edition (instructors only)**

The Annotated Instructor's Edition contains answers to all exercises. The answers to most questions are printed in blue next to each problem. Answers not appearing on the page can be found in the Answer Appendix at the end of the book.

### **Student's Solutions Manual**

Derived from author-approved Connect solutions, this manual contains detailed solutions to all odd-numbered text problems and answers to all Quizzes, Reviews, and Case Study problems found at the end of each chapter.

### **Statistics Corequisite Workbook**

This workbook, co-written by author Barry Monk, is designed to provide corequisite remediation of the necessary skills for an introductory statistics course. The included topics are largely independent of one another and may be used in any order that works best for the instructor. Available online or print copies can be ordered in Create.



## Agricultural/gardening/farming applications. *See also* Forestry

applications  
absorption rate of pesticides into skin, 657  
acid levels of soil, 675  
chicken weights, 317  
fertilizer effect on maple sap production, 670  
fertilizer effect on orange trees, 420, 496, 676  
fertilizer effect on tomato yield, 25  
herbicides and phosphate concentration of bean plants, 517  
pesticides and fruit yields, 672  
phosphorus in soil, 659  
seed germination rate, 340  
temperature and water evaporation, 610, 617  
wheat yields, 685

## Archaeology applications

mummy's curse and life spans, 531–532

## Automotive/motor vehicle applications

accidents at intersections, 505  
accidents per year, 112, 285  
air pollution caused by motor vehicles, 76, 513, 517, 542, 551  
battery lifetimes, 353  
BMW prices, 65, 76  
brake wear and mileage, 512–513  
car repairs, 224, 237, 340  
car speeds and stopping distance, 194  
car speeds and street noise level, 610, 616  
car speeds on highways, 319, 475  
cell phones and driving, 32  
delivery truck load weights, 353  
don't drink and drive, 11, 109  
drag-racing parachutes, 249  
emissions at sea level and high altitude, 149–150, 517, 542  
emissions testing, 277, 629–630  
fuel efficiency, 31, 128, 513, 514  
gas mileage, 32, 92, 128, 197, 326, 387, 689–690  
gas prices, 107  
license plate choices, 245  
new car choice probabilities, 237  
new car sales, 47–48  
new car satisfaction, 334  
new truck sales, 48  
parking on campus, 11  
pickup truck ownership, 237  
pillars giving head protection in cars, 659  
risky drivers, 214  
tire lifetimes, 318, 479, 480  
tires and fuel economy, 31, 513, 514  
tires and number of miles traveled, 676–677  
tires with low air pressure, 265  
tire tread depth, 698–699  
truck pollution, 513, 551  
truck weight and gas mileage, 197, 636

used car ages, 388  
years between accidents, 498, 532

## Aviation applications

airline ticketing policy, 340  
flight delays, 277

## Behavioral study applications. *See also* Psychological applications

dog weights, 420  
don't drink and drive, 11, 109  
nicotine patch to quit smoking, 468  
weight loss during counseling, 456

## Beverage applications

breweries in selected states, 107, 128  
caffeine in coffee, 420  
calories in milkshakes, 374  
carbohydrates in espresso beverages, 148  
coffee prices, 690  
daily coffee consumption, 332  
don't drink and drive, 11, 109  
energy drinks, 374, 497  
moisture content of coffee beans, 479, 480  
strength of aluminum cans, 355  
volume of beverage in can, 318, 456–457, 472–473, 699  
volume of beverage in large-sized sodas, 658

## Biology/life science

applications. *See also* Genetics/gender applications

age of babies beginning to talk, 386  
bird brain weight *versus* body weight, 181  
blood typing system for humans, 44, 249, 278  
butterfly wingspan *versus* lifespan, 169, 180, 609, 616  
Down Syndrome births, 285  
forearm length and height, 197  
gestational age and baby weights, 198  
height and age, 442  
heights of boys and men, 111, 132, 319, 513, 551  
heights of college students, 63, 112  
heights of fathers and sons, 609, 616  
heights of women, 105, 111, 132, 319  
random sampling of animal groups, 10–11  
rats running mazes, 63, 457  
shrimp habitat and water pollution, 516  
weights/lengths of fish, 147, 317, 350, 420  
weights of animals, 443, 458  
weights of girls and women, 110, 442  
weights of newborn babies, 131, 198, 405, 532, 698  
weights of older babies, 278, 317, 340, 373, 386, 456, 472, 497

## Business applications

advertisement views, 480  
advertising expenditures, 108, 154–155  
age discrimination, 587

bond prices, 130  
CEO salaries, 387  
college graduates working at home, 398  
confidence in banks, 467–468  
corporate profits, 153, 155  
credit card balances, 457  
credit card charges, 376  
credit card payments, 409  
credit scores, 195, 456, 633–634  
day and night shifts, 245  
days per year spent traveling, 420  
Dow Jones Industrial Average, 84, 130  
economy in the future, 16, 399, 507, 578  
extending banking hours, 29  
financial literacy, 695  
finding job after job loss, 288  
flextime in company to reduce sick days, 564–565  
free desserts to increase business, 457  
government employee percentages, 333  
hourly wages and/or years employed, 68, 111, 169–170, 376  
inflation rate and unemployment rate, 200–201  
interest in economics, 469  
job changes, 399, 400  
job satisfaction, 214, 483  
job security, 46  
life expectancy, 32  
life insurance, 251–252, 267  
management jobs and gender, 237  
marketing firm survey, 18, 480  
mean and median salaries, 112  
mean federal income tax, 326  
mean state income tax, 353  
multiple jobs held, 333  
on-site day care, 11–12  
opinions of service at a store, 11  
personal incomes, 110, 111, 150  
prime interest rate, 181  
random-digit dialing as sampling method, 29  
restaurant customers on Mondays *versus* Tuesdays, 698  
retail spending, 11, 79  
return on investment, 130  
sales commissions, 565  
sales tax increase, 468  
sales tax on Internet purchases, 468  
satisfaction with financial situation, 506  
saving by U.S. residents, 84–85  
science careers, 475  
spreadsheet testing, 565, 658  
start-up probabilities, 249, 267  
stock market averages and first digits of the number, 290  
stock market crash, 84  
stock prices, 108, 129, 154, 181, 374, 469, 482, 516  
stress at work, 278, 340  
tax return refunds, 12

tax returns and first digits of the number, 291  
tax returns for which no tax paid, 333  
technology salaries, 76  
unemployment rate in U.S., 77  
U.S. imports and exports by month, 193  
weekly earnings, 333  
women in service occupations, 237  
words typed per minute, 375  
workforce increases during economic downturn, 400

## Chemicals/chemistry applications

acid levels of soil, 675  
adhesive bond strength, 671  
ammonium in water wells, 319  
bacteria in pond water, 285  
benzene in wastewater, 496, 531, 565  
calories in fat, 611  
carbon dioxide production and global warming, 168, 179–180  
carbon monoxide concentration, 388  
chemicals in well water, 675–676  
cleaning solutions, 671  
gypsum and acid level, 675  
gypsum and electrical conductivity, 675, 676  
lead in water, 399, 443  
mercury in lakes, 476  
mineral content of kale, 387  
mineral content of spinach, 386, 406  
ozone concentration, 181  
paint drying time, 637  
paint lifetime, 632  
phosphorus in soil, 659  
soap lather, 670–671  
soap weights, 155  
suspended particles, 289  
temperature, concentration, and time in chemical reactions, 633  
temperature and water evaporation, 610, 617

## Computer applications. *See*

Electronics/computer applications

## Construction/home improvement/home purchases and sales applications

air conditioner costs, 698  
apartment rents, 153, 326, 483–484, 685, 695  
asphalt-rubber concrete beam strength, 671  
breaking strength of wood boards, 658  
building new parking structure, 411  
construction site water contamination, 399  
electricity bills/prices, 132, 318  
expansion of concrete over time, 610, 617  
fireplaces and garages, 225  
household income and energy consumed, 198, 637  
house prices, 107–108, 129, 442  
house size and energy expenditures, 193  
house size and selling price, 194  
house sizes, 459, 475  
mortgage payments/rates, 169, 180, 386–387, 406  
radon levels, 194, 318  
recovering from heart attacks in smaller houses, 25

sales price *versus* rental price of homes, 193  
smoke detectors in homes, 279  
vacant apartment rates, 77

## Crime

graffiti by borough, 225  
illegal drug use in high school, 29  
murder rates in cities, 65, 66  
police department effectiveness, 29  
police numbers and crimes committed, 169  
taxicabs and crime rates, 25  
violent crime categories and rates, 578

## Dental applications

fluoride and tooth decay, 32

## Earth science applications

altitude and pollution from cars, 149–150, 517, 542  
floodwater drainage time, 657–658  
geyser eruption durations, 65, 633  
global warming, 16  
humidity and ozone levels, 611, 617  
hurricanes, 78, 542, 695–696  
ice on lakes, 638–639  
silver ore in rock samples, 67  
wind speeds and electric power generated, 640–641

## Education/school applications

absences from school, 592  
adults with degrees, 86, 110  
advanced placement tests, 288  
age and education, 110, 169  
age at high school graduation, 169  
ages of college students, 388, 408, 443–444  
air pollution in Chinese schools, 25  
annual incomes of college graduates, 375  
arithmetic teaching method, 444  
attitudes toward school, 375  
cafeteria food rating, 288  
choosing books to study, 245  
college enrollments, 278, 340  
college freshmen majoring in sciences, 333  
college graduates working at home, 398  
college tuition, 409, 456, 516  
computers in the classroom, 376, 505–506  
confidence in educational institutions, 214  
course selection, 249  
distance learning effectiveness, 497  
educational issues and visits to science museums, 587  
education levels, 47, 385, 591  
energy drinks consumed by college students, 497  
exam scores, 66, 133, 149, 319  
exam score *versus* hours spent studying, 181  
favorite subjects, 670  
female business majors, 249  
final exam scores, 111, 149, 181, 319  
final grade probabilities, 224, 249  
final grades, 111  
gender bias in graduate school admissions, 592–594  
gender differences in attitudes and behaviors, 562  
girls enrolled in elementary school, 354  
grade distributions, 577–578

grade point averages, 306–307, 375, 443, 631–632  
graduate salaries *versus* years of experience, 181  
heights of college students, 63, 112  
high school dropouts, 237  
high school freshmen graduating with their class, 332–333  
homework not completed by college freshmen, 89  
homework score, 111  
homework submitted electronically, 32  
hours of sleep, 387, 412  
hours spent studying or reading, 181, 318–319, 388  
illegal drug use in high school, 29  
IQ test scores, 405, 421, 472, 497, 531, 559  
male *versus* female college students, 77–78  
math skills testing, 412, 442, 695  
multiple choice questions, 29, 267, 277  
number of siblings, 66  
online learning courses, 385  
ordering of supplies, 31  
parking on campus, 11  
phonics, 386  
quiz scores, 89  
reading skills, 11, 288, 350, 399, 542  
recreation fee increase, 11  
required courses, 250  
satisfaction with college life, 469  
SAT math preparation, 444, 513–514, 551–552  
SAT math scores, 111, 181, 326, 373, 399, 405, 442–443, 472, 479, 480  
SAT score and language study, 198  
SAT verbal scores, 181  
saving for college, 475  
school enrollment by grade, 267  
sick children in class, 224  
software instruction hours, 386  
standardized test scores, 147  
student executive committee choices, 245  
student loans, 332  
teacher salaries, 475  
tenth-graders planning to attend college, 400–401  
tests online *versus* on paper, 497–498, 532  
text messages sent by teenagers, 266  
true–false exam questions, 214, 277, 578  
tuition and fees of private colleges, 456  
vocabulary and height of elementary students, 25  
weight gain or loss during freshman year, 697  
working college students, 469  
years of education for adults, 385

## Elderly/older-person applications

prescription drug program, 11

## Electronics/computer applications

ages of video gamers, 46  
battery lifetimes, 306, 327, 353  
bias in phone polls, 29  
Blu-ray load times, 690  
CD sales, 84  
cell phone batteries, 154



cell phone features, 11  
cell phone ownership by children, 399, 468  
cell phones in purchasing decisions, 277  
changing jobs, 399  
computer chips, 153–154, 543  
computer crashes, 496–497  
computer data backup, 46–47  
computer passwords, 246  
computer purchases, 224  
computer virus/worm, 11, 224  
defective circuits, 249, 266  
defective electronic components, 412, 506  
delivery of products from e-store, 29  
drone delivery of packages, 375  
eCommerce spending, 127  
electronics lifetimes, 374  
Facebook apps, 106  
Facebook usage, 105, 106, 354, 482  
flickering screen on DVR, 285  
freeze-up times for computers, 559  
Google search engine usage, 277, 339–340  
HDTV screen sizes, 387  
homework submitted electronically, 32  
hours spent on Internet, 531  
households with computers, 373  
Instagram followers, 47  
Internet browsers, 88–89  
Internet provider cost, 131  
Internet radio subscribers, 66  
Internet service interruptions, 398  
interpreting calculator display, 180–181, 199, 375, 388, 400, 443, 457–458, 468–469, 483, 498–499, 506–507, 514, 517, 518, 532–533, 542–543, 552, 565–566, 567, 610–611, 637–638  
interpreting computer output, 375–376, 388, 400, 443–444, 458, 469, 483, 498, 507, 514, 517, 518, 533, 543, 552, 566–567, 638  
microprocessor speed, 512  
mobile (smartphone) apps, 11, 106  
Netflix usage, 442  
PIN codes, 238  
posting photos online, 468  
random-digit dialing as sampling method, 29  
semiconductor wafer quality control, 236  
smartphone ownership, 332, 398  
smartphone prices, 373  
smartphone sales, 45  
social media usage, 457–458, 506  
spam in email, 467  
technology salaries, 76  
text messages, 266, 443, 459, 532  
time spent playing video games, 64–65, 66  
top ten video games, 17  
Twitter usage, 47, 285, 385–386, 468  
video game consoles, 468  
video games sales, 17, 44, 45, 46  
website ratings, 31

**Entertainment applications.** *See also* Gambling applications  
ages of Grammy Award winners, 325–326  
ages of video gamers, 46  
Blu-ray load times, 690  
Broadway shows, 110, 193–194  
cable news viewing, 484  
cable television choices, 468

digital music sales, 47, 84, 85, 90–91  
Dungeons & Dragons, 215  
favorite newscaster, 32  
favorite performer, 31  
favorite television show, 106, 128–129  
federal support for arts and culture, 153, 167–168, 179  
football stadium seating, 149  
Halloween costumes, 48, 387  
Internet radio subscribers, 66  
League of Legends game critical strikes, 399  
movie running times, 76–77, 386, 684  
music video viewing, 16  
Pokémon characters, 149  
random playing of songs, 236, 249  
recreation fee increase, 11  
roller coaster weight carried safely, 326  
SpongeBob picture recognition, 213, 237  
Squidward Tentacles picture recognition, 237  
Super Bowl on television, 45, 412  
target practice, 237  
television sets in households, 326, 483  
television viewing habits, 11, 458  
tic-tac-toe, 237  
time spent playing video games, 64–65, 66  
time spent watching television, 456, 458, 472, 565  
top-grossing movies, 17, 76–77  
top ten video games, 17  
video game consoles, 468  
video game sales, 17, 44, 45, 46

### Environmental applications

air pollution and colds, 25  
air pollution and respiratory health, 33–34  
air pollution caused by motor vehicles, 76, 513, 517, 542, 551  
air pollution in Chinese schools, 25  
air pollution standards, 266  
benzene in wastewater, 496, 531, 565  
carbon dioxide production and global warming, 168, 179–180  
carbon monoxide concentration, 388  
construction site water contamination, 399  
contaminated wells, 319  
environmental restoration cost, 411  
fine particle air pollution, 149  
floodwater drainage time, 657–658  
fracking, 630–631  
fuel tank leaks, 412  
global warming, 16  
hazardous waste sites, 147–148  
humidity and ozone levels, 611, 617  
ice on lakes, 638–639  
ice sheet coverage in Arctic, 79  
interest in environmental issues and science museum visits, 587  
lead in water, 399, 443  
mercury in lakes, 476  
microorganism diversity, 699  
ozone in atmosphere, 181, 611, 617  
particulate matter air pollution, 32–33, 76, 638  
PCB contamination in water, 411  
power plant emission levels, 658, 676  
secondhand smoke, 25  
shrimp habitat and water pollution, 516

vehicle emissions at low and high altitudes, 149–150, 517, 542  
wastewater treatment, 699  
wood stove pollution, 413–414

**Exercise applications.** *See* Sports/exercise/fitness applications

**Farming applications.** *See* Agricultural/gardening/farming applications

**Fitness applications.** *See* Sports/exercise/fitness applications

**Food applications.** *See also* Beverage applications

cafeteria food rating, 288  
calories in bread, 409  
calories in fat, 611  
calories in hamburgers, 105  
chocolate chips in each cookie, 285  
eggs and milk prices, 167, 179  
family food expenditures, 44  
fast-food chain outlets, 236  
food spending by U.S. residents, 78, 86  
free desserts to increase business, 457  
grams in boxes of crackers, 483  
hot dog eating contest, 85  
ice cream flavors, 245  
mineral content of kale, 387  
mineral content of spinach, 386, 406  
ounces of cereal in boxes, 327, 386, 405–406  
ounces of cookies in box, 475  
pizza toppings, 245  
pretzels in advertising campaign, 506  
protein and calories in fast-food products, 609, 616  
restaurant food rating, 29  
restaurant outlets by city population and location, 236  
restaurant spending, 420  
spending on lunch, 130, 131  
sugar content of selected products, 483, 558–559  
sugar in apples, 409  
vegetables and colon cancer, 25  
weight of bag of apples, 327

### Forestry applications

breaking strength of wood boards, 658  
cost of restoration of forests, 411  
flaws in lumber, 284–285  
tree heights, 318, 685  
trees of certain species in forest, 285  
volume of lumber in trees, 197, 636–637

### Gambling applications.

*See also* Entertainment applications  
blackjack, 246  
coin tossing, 213, 214, 215, 340, 400, 421, 469  
craps, 267, 288  
dice rolling, 214, 215, 223–224, 249, 578–579  
horse racing, 245  
lottery profits, 267  
lottery tickets sold, 288  
lottery winnings, 111–112, 237, 246



Mega Millions lottery, 577, 592  
roulette, 213, 214  
Texas hold 'em, 246  
tribal casinos, 148–149

### **Gardening applications.** *See*

Agricultural/gardening/farming applications

### **Genetics/gender applications**

birth order and intelligence, 497, 531, 559  
boys *versus* girls in families of four children, 590  
boys *versus* girls in families of three children, 267–268  
DNA sequences, 246, 588  
dominant/recessive genes, 236  
gender bias in graduate school admissions, 592–594  
gender differences in attitudes and behaviors, 562  
gender of business majors, 249  
gender of senators, 85, 400  
heights of fathers and sons, 609, 616  
high school dropouts by gender, 237  
male *versus* female college students, 77–78  
management jobs and gender, 237  
maternal age at time of first birth, 468–469  
mutant genes and age, 192–193  
mutation causing deafness, 289  
pea plants genetic studies, 340  
political party affiliation and gender, 224, 236  
service occupation jobs, 237  
sickle-cell anemia carriers, 288

### **Health/healthcare**

**applications.** *See also* Medical/medical research/alternative medicine applications  
absorption rate of pesticides into skin, 657  
air pollution and colds, 25  
air pollution and respiratory health, 33–34  
alcohol and liver disease, 26  
beryllium disease, 587  
blood pressure by age, 149  
blood pressure in men/women, 63, 147, 317  
body mass index of adults with diabetes, 497  
cancer and life expectancy, 91  
carbon monoxide exposure and symptoms reported, 587  
childhood obesity, 541  
cholesterol levels, 63, 148, 326, 373, 542, 611, 617  
cold medications, 25  
days of coughing after acute cough illness, 66  
days of pain suffered before seeking medical treatment, 266–267  
deaths due to smoking, 214  
diet effectiveness, 458  
drug to lower blood pressure, 459  
exercise and blood pressure, 24–25, 698  
exercise and heart rate, 516  
flu types, 108  
foot ulcers and foot temperatures, 168–169, 180  
headache drug testing, 11  
health-care proposal opinions, 32  
heart attacks by age and gender, 250

heavy children, 442  
high blood pressure probabilities, 278, 333, 340  
hospital births by gender, 334  
hours of relaxation per day, 266  
hours of sleep, 387, 412, 458  
lead in water, 399, 443  
life expectancy, 32, 105  
low-fat *versus* low-carb diets, 497, 531  
lung function measurement, 442  
nicotine patch to quit smoking, 468  
pneumonia patients under age 18, 409  
prescription drug program, 11  
recovering from heart attacks in smaller houses, 25  
secondhand smoke, 25  
sleep apnea, 398  
stress at work, 278, 340  
systolic/diastolic blood pressure measurements, 63, 169, 180, 609, 616  
trust in doctors, 88  
waist size of men, 412  
weight loss diets and programs, 375–376, 444, 458, 496, 497, 531, 684

### **Home improvement.** *See*

Construction/home improvement/home purchases and sales applications

### **Home purchases and sales**

**applications.** *See* Construction/home improvement/home purchases and sales applications

### **Library/book applications**

age and visits to library, 224  
age of college library books, 443  
best graphic novels, 17  
books arranged on bookshelf, 250  
choosing books to study, 245  
favorite types of books, 110  
funny sounding and interesting words, 17  
library hours changes, 12  
magazine subscription cost, 108–109  
newspaper circulation, 108  
reviewing articles for a journal, 130  
thickness of pages in a book, 327

### **Life science applications.** *See*

Biology/life science applications

### **Manufacturing applications**

ball bearing diameters, 319  
battery lifetimes, 327  
breaking strength of bolts, 567  
breaking strength of wires, 420  
calibration of a scale, 420–421, 442  
ceramic tiles, 334  
component design and materials, 672  
component repair costs, 411, 412  
defective products, 237, 249, 266, 278–279, 350, 354, 412, 506, 562  
delivery truck load weights, 353  
drill lifetimes, 411  
efficiency of processes, 374  
expansion of concrete over time, 610, 617  
flaws in aluminum foil, 284  
flaws in aluminum parts, 224

impurities in aluminum cans, 350  
ladies' shoe sizes, 476  
lightbulb lifetimes, 353  
microbalance performance, 677–678  
product rating, 588  
quality control, 11, 236, 591, 677  
rivet length, 154  
shipping speed and quality, 672  
steel rod lengths/diameters, 565  
strength of concrete, 399, 513, 551, 671, 690  
washer thicknesses, 420  
weights obtained on different scales, 517, 551  
wood stove pollution, 413–414

### **Medical/medical research/alternative medicine**

**applications.** *See also* Health/healthcare applications

alcohol and liver disease, 26  
angioplasty to treat circulatory disease, 542  
annual earnings of doctors, 456  
antifungal drug testing, 457  
artificial hip ball wear, 657, 658  
beryllium disease, 587  
blood typing system for humans, 44, 249, 278  
body mass index of adults with diabetes, 497  
brain cancer and electrical field exposure, 568  
cancer and life expectancy, 91  
cholesterol lowering drugs, 373, 479–480, 513  
choosing doctors, 468  
cold medications, 25  
colonoscopy effectiveness, 506  
coronary bypass surgery, 278, 698  
crossover trials to compare drugs, 550–551  
days of coughing after acute cough illness, 66  
disease test results, 238  
dosages administered by syringe, 353  
Down Syndrome births, 285  
drug concentration in bloodstream, 350  
drug half-life, 473  
drugs to prevent heart attacks or strokes, 542  
drug to lower blood pressure, 459  
flu types, 108  
foot ulcers and foot temperatures, 168–169, 180  
headache drug testing, 11  
health of former *versus* current smokers, 26  
heart attacks by age and gender, 250  
hip surgery times, 386  
hospital admissions by reason, 46  
hospital births by gender, 334  
hospital stay costs, 193  
hospital stay lengths, 458  
hospitals winning safety awards, 77  
hospital visits related to asthma, 215  
kidney transplants, 333–334  
knee surgery complications, 399  
life expectancy, 91, 105  
lung function measurement, 442  
nicotine patch to quit smoking, 468  
outcomes of surgery in hospitals, 591  
pain reliever effectiveness, 24, 387

pain reliever half-life, 387, 473  
pneumonia patients under age 18, 409  
polio vaccine trials, 26  
postoperative pain, 506  
postoperative treatment for surgical patients, 444  
postsurgical recovery times of patients, 517, 531, 690, 698  
prescription drug program, 11  
radon and cancer, 194  
recovering from heart attacks in smaller houses, 25  
reducing stomach volume to cure diabetes, 468  
Salk vaccine trials, 26  
sickle-cell anemia carriers, 288  
side effects of medical procedure, 354  
sleep apnea, 398  
sugar content of pharmaceutical products, 657  
surgical procedure time, 154  
treadmill walking to alleviate claudication, 531, 565  
treatments to prevent heart failure, 519  
trust in doctors, 88  
vegetables and colon cancer, 25

### Miscellaneous applications

age at death, 66  
ages at death for British monarchs, 90  
committee officer choices, 246  
confidence intervals/levels in sampling, 374–375  
customer service survey, 11  
customers in express checkout line, 265–266  
dogs in households, 685  
Empirical Rule, 131–132  
false fire alarms, 578  
family size, 587  
first digits of numbers, 289–291  
fraud complaint rates, 685  
household income, 105, 150  
household income and energy consumed, 198, 637  
job interview probabilities, 236  
languages spoken in households, 48  
laundry costs, 690  
marketing firm survey, 18  
mean absolute deviation, 132  
newspaper circulation, 108  
number of people in households, 375, 458, 482–483  
personal incomes, 110, 111, 150, 327  
planet distances from sun, 126  
probabilities of events, 213  
proportion of females in U.S. population, 48  
raffle tickets, 11  
refrigerator costs, 457  
residents of geographic regions of U.S., 578  
retail spending, 11, 79  
reviewing articles for a journal, 130  
shopping at the mall, 11  
sources of current event news, 110  
spending on gifts, 79, 109  
spending online, 127  
spending on lunch, 130, 131  
spreadsheet task completion time, 350  
standard deviation, 132

state populations, 289–291, 388  
tattoos among adults, 468  
timing of bills payments, 131, 214  
U.S. population by geographic region, 45  
volunteer work, 398–399

### Motor vehicle applications. *See*

Automotive/motor vehicle applications

### Nuclear applications

nuclear power plant construction, 29  
nuclear reactors in selected countries, 148

### Political applications

abortion policy, 578  
ages of U.S. presidents and their wives, 192  
ages of U.S. presidents at death, 90  
approval ratings for Congress, 685  
economic future polls, 399, 507, 578  
election reform, 29  
electoral votes cast, 79–80  
female senators, 85, 400  
freshmen in House of Representatives, 89–90  
government spending, 44–45  
handling of economy by U.S. Congress, 29  
health-care proposal opinions, 32  
heights of U.S. presidents, 388  
immigration policy, 11  
Literary Digest political polling, 29–30  
mayoral elections, 213–214  
military spending, 77  
number of words in inaugural speeches, 65–66, 149  
order of choices in political polling, 29  
party affiliation and gender of senators, 224–225, 236  
political debates, 469  
satisfaction with presidential candidates, 399  
smoking in public places, 587  
voter preferences on candidates, 11, 31, 213–214, 354, 399, 400, 469  
voter preferences on selected issues, 340, 517, 565  
votes for incumbent, 400  
women's effectiveness at governing, 400

### Psychological applications. *See*

*also* Behavioral study applications  
attitudes toward school, 375  
choosing doctors, 468  
empathy types, 532  
IQ test scores, 405, 421, 472, 497, 531, 559  
optimism about the future, 588–589  
reaction times to visual and auditory stimuli, 610, 617  
weight loss during counseling, 456

### Safety applications

car accidents at intersections, 505  
car accidents per year, 112, 285  
car speed and stopping distance, 194  
delivery truck load weights, 353  
don't drink and drive, 11  
elevator weight carried safely, 326  
hospitals winning safety awards, 77  
pillars giving head protection in cars, 659  
roller coaster weight carried safely, 326

seat belt effectiveness, 29  
seat belt use, 400  
years between car accidents, 498, 532

**School applications.** *See* Education/  
school applications

### Sociological applications

age and education, 110, 169  
age distribution, 109, 130  
ages of tennis and golf champions, 76  
ages of video gamers, 46  
ages when women first marry, 85–86  
birth rates, 91  
birth rates after hurricane, 695–696  
cell phone ownership by children, 399  
changing jobs, 399, 400  
gender differences in attitudes and behaviors, 562  
languages spoken in households, 48  
number of children, 150, 214–215, 225, 388, 587  
number of people in households, 375, 458, 482–483  
number of siblings, 66, 126–127, 587  
poverty rates, 89  
smoking in public places, 587  
world population, 46

### Sports/exercise/fitness applications

ages of tennis and golf champions, 76  
baseball batting averages, 64, 66  
baseball pitches, 214  
baseball runs scored, 482, 698  
baseball salaries, 149  
basketball three-point shots, 79  
bowling scores, 111, 237  
exercise and blood pressure, 24–25, 698  
exercise and heart rate, 516  
exercise and weight, 695  
football stadium seating, 149  
football turnover margins and wins, 198  
heights of football players, 168, 179  
hockey stick breaking strength, 559  
margin of victory in Olympic swimming events, 105  
Olympic athletes/participation by country, 64, 78  
Olympic gold medal winners, 78  
soccer goals scored, 267  
Super Bowl on television, 45, 412  
tennis ball circumference, 154  
treadmill walking to alleviate claudication, 531, 565  
weight-loss programs, 496  
weights of football players, 108, 128, 168, 179, 408  
weights of soccer players, 388

### Travel applications

bus route changes, 11  
car accidents at intersections, 505  
car accidents per year, 112, 285  
carpool occupants, 266  
car speed and street noise level, 610, 616  
car speeds on highways, 319, 475

cell phones and driving, 32  
commuting to work in miles/times, 66, 148,  
199, 319, 327, 456, 458, 685, 698  
fuel efficiency, 31, 128, 513, 514  
gas prices, 107  
potholes in street, 284  
risky drivers, 214  
tire lifetimes, 318, 479, 480  
tires and fuel economy, 31, 513, 514

traffic during morning *versus* evening rush  
hours, 695  
traffic lights, 222, 237  
years between car accidents, 498, 532

### **Weather applications**

daily high temperatures, 64, 76, 77  
days of rain, 288, 412  
humidity and ozone levels, 611, 617

mean temperature, 132  
monthly rainfall, 151  
rain probability, 250  
snowfall amounts, 78–79, 542  
summer temperatures, 325  
temperature and barometric  
pressure, 192  
temperature warming trends, 484–485  
wind speeds, 148, 409

# Basic Ideas

chapter

# 1



©Tatiana Grozetskaya/Shutterstock

## Introduction

How does air pollution affect your health? Over the past several decades, scientists have become increasingly convinced that air pollution is a serious health hazard. The World Health Organization has estimated that air pollution causes 2.4 million deaths each year. The health effects of air pollution have been investigated by measuring air pollution levels and rates of disease, then using statistical methods to determine whether higher levels of pollution lead to higher rates of disease.

Many air pollution studies have been conducted in the United States. For example, the town of Libby, Montana, was the focus of a recent study of the effect of particulate matter—air pollution that consists of microscopic particles—on the respiratory health of children. As part of this study, parents were asked to fill out a questionnaire about their children’s respiratory symptoms. It turned out that children exposed to higher levels of particulate pollution were more likely to exhibit symptoms of wheezing, as shown in the following table.

Level of Exposure	Percentage with Symptoms
High	8.89%
Low	4.56%

The rate of symptoms was almost twice as high among those exposed to higher levels of pollution. At first, it might seem easy to conclude that higher levels of pollution cause

symptoms of wheezing. However, drawing accurate conclusions from information like this is rarely that simple. The case study at the end of this chapter will present more complete information and will show that additional factors must be considered.

## Section

## Sampling

# 1.1

### Objectives

1. Construct a simple random sample
2. Determine when samples of convenience are acceptable
3. Describe stratified sampling, cluster sampling, systematic sampling, and voluntary response sampling
4. Distinguish between statistics and parameters

In the months leading up to an election, polls often tell us the percentages of voters that prefer each of the candidates. How do pollsters obtain this information? The ideal poll would be one in which every registered voter were asked his or her opinion. Of course, it is impossible to conduct such an ideal poll, because it is impossible to contact every voter. Instead, pollsters contact a relatively small number of voters, usually no more than a couple of thousand, and use the information from these voters to predict the preferences of the entire group of voters.

The process of polling requires two major steps. First, the voters to be polled must be selected and interviewed. In this way the pollsters collect information. In the second step, the pollsters analyze the information to make predictions about the upcoming election. Both the collection and the analysis of the information must be done properly for the results to be reliable. The field of statistics provides appropriate methods for the collection, description, and analysis of information.

### DEFINITION

**Statistics** is the study of procedures for collecting, describing, and drawing conclusions from information.

The polling problem is typical of a problem in statistics. We want some information about a large group of individuals, but we are able to collect information on only a small part of that group. In statistical terminology, the large group is called a *population*, and the part of the group on which we collect information is called a *sample*.

### EXPLAIN IT AGAIN

#### Why do we draw samples?

It's usually impossible to examine every member of a large population. So we select a group of a manageable size to examine. This group is called a sample.

### DEFINITION

- A **population** is the entire collection of individuals about which information is sought.
- A **sample** is a subset of a population, containing the individuals that are actually observed.

Ideally, we would like our sample to represent the population as closely as possible. For example, in a political poll, we would like the proportions of voters preferring each of the candidates to be the same in the sample as in the population. Unfortunately, there are no methods that can guarantee that a sample will represent the population well. The best we can do is to use a method that makes it very likely that the sample will be similar to the population. The best sampling methods all involve some kind of random selection. The most basic, and in many cases the best, sampling method is the method of **simple random sampling**.



**Objective 1** Construct a simple random sample

## Simple Random Sampling

To understand the nature of a simple random sample, think of a lottery. Imagine that 10,000 lottery tickets have been sold, and that 5 winners are to be chosen. What is the fairest way to choose the winners? The fairest way is to put the 10,000 tickets in a drum, mix them thoroughly, then reach in and draw 5 tickets out one by one. These 5 winning tickets are a simple random sample from the population of 10,000 lottery tickets. Each ticket is equally likely to be one of the 5 tickets drawn. More importantly, each collection of 5 tickets that can be formed from the 10,000 is equally likely to comprise the group of 5 that is drawn.

### DEFINITION

A **simple random sample** of size  $n$  is a sample chosen by a method in which each collection of  $n$  population items is equally likely to make up the sample, just as in a lottery.

Since a simple random sample is analogous to a lottery, it can often be drawn by the same method now used in many lotteries: with a computer random number generator. Suppose there are  $N$  items in the population. We number the items 1 through  $N$ . Then we generate a list of random integers between 1 and  $N$ , and choose the corresponding population items to comprise the simple random sample.

### Example 1.1

#### Choosing a simple random sample

There are 300 employees in a certain company. The Human Resources department wants to draw a simple random sample of 20 employees to fill out a questionnaire about their attitudes toward their jobs. Describe how technology can be used to draw this sample.

#### **Solution**

**Step 1:** Make a list of all 300 employees, and number them from 1 to 300.

**Step 2:** Use a random number generator on a computer or a calculator to generate 20 random numbers between 1 and 300. The employees who correspond to these numbers comprise the sample.

### Example 1.2

#### Determining whether a sample is a simple random sample

A physical education professor wants to study the physical fitness levels of students at her university. There are 20,000 students enrolled at the university, and she wants to draw a sample of size 100 to take a physical fitness test. She obtains a list of all 20,000 students, numbered from 1 to 20,000. She uses a computer random number generator to generate 100 random integers between 1 and 20,000, then invites the 100 students corresponding to those numbers to participate in the study. Is this a simple random sample?

#### **Solution**

Yes, this is a simple random sample because any group of 100 students would have been equally likely to have been chosen.

### Example 1.3

#### Determining whether a sample is a simple random sample

The professor in Example 1.2 now wants to draw a sample of 50 students to fill out a questionnaire about which sports they play. The professor's 10:00 A.M. class has 50 students. She uses the first 20 minutes of class to have the students fill out the questionnaire. Is this a simple random sample?

### Solution

No. A simple random sample is like a lottery, in which each student in the population has an equal chance to be part of the sample. In this case, only the students in a particular class had a chance to be in the sample.

### Example 1.4

### In a simple random sample, all samples are equally likely

To play the Colorado Lottery Lotto game, you must select six numbers from 1 to 42. Then lottery officials draw a simple random sample of six numbers from 1 to 42. If your six numbers match the ones in the simple random sample, you win the jackpot. Sally plays the lottery and chooses the numbers 1, 2, 3, 4, 5, 6. Her friend George says that this isn't a good choice, since it is very unlikely that a random sample will turn up the first six numbers. Is he right?

### Solution

No. It is true that the combination 1, 2, 3, 4, 5, 6 is unlikely, but every other combination is equally unlikely. In a simple random sample of size 6, every collection of six numbers is equally likely (or equally unlikely) to come up. So Sally has the same chance as anyone to win the jackpot.

### Example 1.5

### Using technology to draw a simple random sample

Use technology to draw a simple random sample of five employees from the following list.

1. Dan Aaron	11. Johnny Gaines	21. Jorge Ibarra	31. Edward Shingleton
2. Annie Bienh	12. Carlos Garcia	22. Maurice Jones	32. Michael Speciale
3. Oscar Bolivar	13. Julio Gonzalez	23. Jared Kerns	33. Andrew Steele
4. Dominique Bonnaud	14. Jacqueline Gordon	24. Kevin King	34. Neil Swain
5. Paul Campbell	15. James Graves	25. Frank Lipka	35. Sherry Thomas
6. Jeffrey Carnahan	16. Ronald Harrison	26. Carl Luther	36. Shequiea Thompson
7. Joel Chae	17. Andrew Huang	27. Laverne Mitchell	37. Barbara Tilford
8. Dustin Chen	18. Anthony Hunter	28. Zachary Quesada	38. Jermaine Tryon
9. Steven Coleman	19. Jonathan Jackson	29. Donnell Romaine	39. Lizbet Valdez
10. Richard Davis	20. Bruce Johnson	30. Gary Sanders	40. Katelyn Yu

### Solution

We will use the TI-84 Plus graphing calculator. The step-by-step procedure is presented in the Using Technology section on page 9. We begin by choosing a **seed**, which is a number that the calculator uses to get the random number generator started. Display (a) shows the seed being set to 21. (The seed can be chosen in almost any way; this number was chosen by looking at the seconds display on a digital watch.) Display (b) presents the five numbers in the sample.

```
21→rand
```

(a)

```
randInt(1,40,5)  
{27 39 30 35 17}
```

(b)

The simple random sample consists of the employees with numbers 27, 39, 30, 35, and 17. These are Laverne Mitchell, Lizbet Valdez, Gary Sanders, Sherry Thomas, and Andrew Huang.

### CAUTION

If you use a different type of calculator, a different statistical package, or a different seed, you will get a different random sample. This is perfectly all right. So long as the sample is drawn by using a correct procedure, it is a valid random sample.

**Objective 2** Determine when samples of convenience are acceptable

## Check Your Understanding

1. A pollster wants to estimate the proportion of voters in a certain town who are Democrats. He goes to a large shopping mall and approaches people to ask whether they are Democrats. Is this a simple random sample? Explain.
2. A telephone company wants to estimate the proportion of customers who are satisfied with their service. They use a computer to generate a list of random phone numbers and call those people to ask them whether they are satisfied. Is this a simple random sample? Explain.

Answers are on page 12.

## Samples of Convenience

In some cases, it is difficult or impossible to draw a sample in a truly random way. In these cases, the best one can do is to sample items by some convenient method. A sample obtained in such a way is called a *sample of convenience*.

### DEFINITION

A **sample of convenience** is a sample that is not drawn by a well-defined random method.

### Example 1.6



©Creatas/Jupiter Images RF

### Drawing a sample of convenience

A construction engineer has just received a shipment of 1000 concrete blocks, each weighing approximately 50 pounds. The blocks have been delivered in a large pile. The engineer wishes to investigate the crushing strength of the blocks by measuring the strengths in a sample of 10 blocks. Explain why it might be difficult to draw a simple random sample of blocks. Describe how the engineer might draw a sample of convenience.

#### Solution

To draw a simple random sample would require removing blocks from the center and bottom of the pile, which might be quite difficult. One way to draw a sample of convenience would be to simply take 10 blocks off the top of the pile.

### Problems with samples of convenience

The big problem with samples of convenience is that they may differ systematically in some way from the population. For this reason, samples of convenience should not be used, except in some situations where it is not feasible to draw a random sample. When it is necessary to draw a sample of convenience, it is important to think carefully about all the ways in which the sample might differ systematically from the population. If it is reasonable to believe that no important systematic difference exists, then it may be acceptable to treat the sample of convenience as if it were a simple random sample. With regard to the concrete blocks, if the engineer is confident that the blocks on the top of the pile do not differ systematically in any important way from the rest, then he can treat the sample of convenience as a simple random sample. If, however, it is possible that blocks in different parts of the pile may have been made from different batches of mix, or may have different curing times or temperatures, a sample of convenience could give misleading results.

### CAUTION

Don't use a sample of convenience when it is possible to draw a simple random sample.

### SUMMARY

- A sample of convenience may be acceptable when it is reasonable to believe that there is no systematic difference between the sample and the population.
- A sample of convenience is not acceptable when it is possible that there is a systematic difference between the sample and the population.

**Objective 3** Describe stratified sampling, cluster sampling, systematic sampling, and voluntary response sampling

## Some Other Sampling Methods

### Stratified sampling

In **stratified sampling**, the population is divided into groups, called **strata**, where the members of each stratum are similar in some way. Then a simple random sample is drawn from each stratum. Stratified sampling is useful when the strata differ from one another, but the individuals within a stratum tend to be alike.

#### Example 1.7

#### Drawing a stratified sample

A company has 1000 employees, of whom 800 are full-time and 200 are part-time. The company wants to survey 50 employees about their opinions regarding benefits. Attitudes toward benefits may differ considerably between full-time and part-time employees. Why might it be a good idea to draw a stratified sample? Describe how one might be drawn.

#### Solution

If a simple random sample is drawn from the entire population of 1000 employees, it is possible that the sample will contain only a few part-time employees, and their attitudes will not be well represented. For this reason, it might be advantageous to draw a stratified sample. To draw a stratified sample, one would use two strata. One stratum would consist of the full-time employees, and the other would consist of the part-time employees. A simple random sample would be drawn from the full-time employees, and another simple random sample would be drawn from the part-time employees. This method guarantees that both full-time and part-time employees will be well represented.

#### EXPLAIN IT AGAIN

**Example of a cluster sample:** Imagine drawing a simple random sample of households, and interviewing every member of each household. This would be a cluster sample, with the households as the clusters.

### Cluster sampling

In **cluster sampling**, items are drawn from the population in groups, or clusters. Cluster sampling is useful when the population is too large and spread out for simple random sampling to be feasible. Cluster sampling is used extensively by U.S. government agencies in sampling the U.S. population to measure sociological factors such as income and unemployment.

#### Example 1.8

#### Drawing a cluster sample

To estimate the unemployment rate in a county, a government agency draws a simple random sample of households in the county. Someone visits each household and asks how many adults live in the household, and how many of them are unemployed. What are the clusters? Why is this a cluster sample?

#### Solution

The clusters are the groups of adults in each of the households in the county. This is a cluster sample because a simple random sample of clusters is selected, and every individual in each selected cluster is part of the sample.

#### EXPLAIN IT AGAIN

**The difference between cluster sampling and stratified sampling:** In both cluster sampling and stratified sampling, the population is divided into groups. In stratified sampling, a simple random sample is chosen from each group. In cluster sampling, a random sample of groups is chosen, and every member of the chosen groups is sampled.

### Systematic sampling

Imagine walking alongside a line of people and choosing every third one. That would produce a **systematic sample**. In a systematic sample, the population items are ordered. It is decided how frequently to sample items; for example, one could sample every third item, or every fifth item, or every hundredth item. Let  $k$  represent the sampling frequency. To begin the sampling, choose a starting place at random. Select the item in the starting place, along with every  $k$ th item after that.

Systematic sampling is sometimes used to sample products as they come off an assembly line, in order to check that they meet quality standards.

## Example 1.9

## Describe a systematic sample

Automobiles are coming off an assembly line. It is decided to draw a systematic sample for a detailed check of the steering system. The starting point will be the third car, then every fifth car after that will be sampled. Which cars will be sampled?

### Solution

We start with the third car, then count by fives to determine which cars will be sampled. The sample will consist of cars numbered 3, 8, 13, 18, and so on.



©Digital Visions

## Voluntary response sampling

**Voluntary response samples** are often used by the media to try to engage the audience. For example, a news commentator will invite people to tweet an opinion, or a radio announcer will invite people to call the station to say what they think. How reliable are voluntary response samples? To put it simply, *voluntary response samples are never reliable*. People who go to the trouble to volunteer an opinion tend to have stronger opinions than is typical of the population. In addition, people with negative opinions are often more likely to volunteer their responses than those with positive opinions.

Figures 1.1–1.4 illustrate several valid methods of sampling.

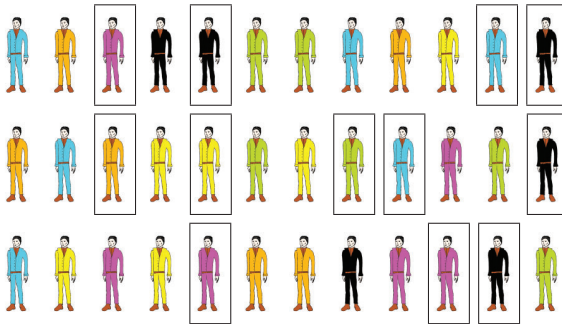


Figure 1.1 Simple random sampling

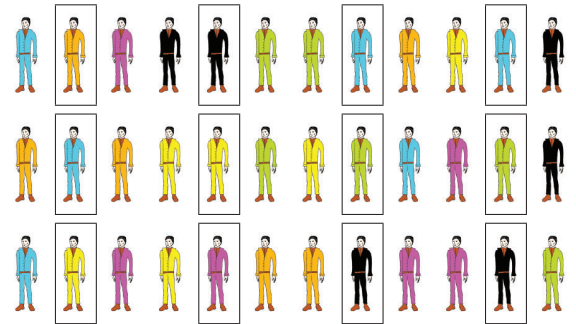


Figure 1.2 Systematic sampling

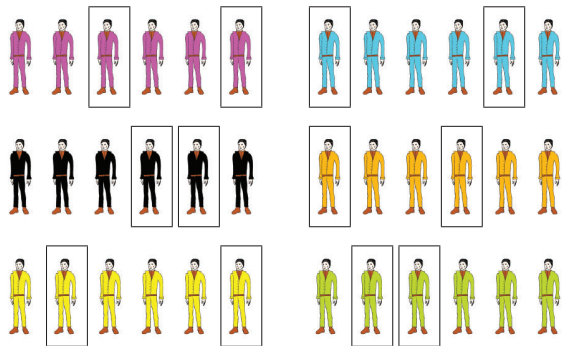


Figure 1.3 Stratified sampling

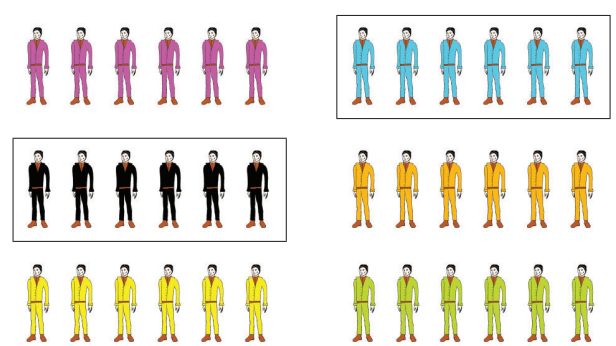


Figure 1.4 Cluster sampling

## Check Your Understanding

3. A radio talk show host invites listeners to send an email to express their opinions on an upcoming election. More than 10,000 emails are received. What kind of sample is this?



4. Every 10 years, the U.S. Census Bureau attempts to count every person living in the United States. To check the accuracy of their count in a certain city, they draw a sample of census districts (roughly equivalent to a city block) and recount everyone in the sampled districts. What kind of sample is formed by the people who are recounted?
5. A public health researcher is designing a study of the effect of diet on heart disease. The researcher knows that the diets of men and women tend to differ, and that men are more susceptible to heart disease. To be sure that both men and women are well represented, the study comprises a simple random sample of 100 men and another simple random sample of 100 women. What kind of sample do these 200 people represent?
6. A college basketball team held a promotion at one of its games in which every twentieth person who entered the arena won a free basketball. What kind of sample do the winners represent?

Answers are on page 12.

## Simple random sampling is the most basic method

Simple random sampling is not the only valid method of random sampling. But it is the most basic, and we will focus most of our attention on this method. From now on, unless otherwise stated, the terms *sample* and *random sample* will be taken to mean *simple random sample*.

**Objective 4** Distinguish between statistics and parameters

## Statistics and Parameters

We often use numbers to describe, or summarize, a sample or a population. For example, suppose that a pollster draws a sample of 500 likely voters in an upcoming election, and 68% of them say that the state of the economy is the most important issue for them. The quantity “68%” describes the sample. A number that describes a sample is called a *statistic*.

### DEFINITION

A **statistic** is a number that describes a sample.

Now imagine that the election takes place, and that one of the items on the ballot is a proposition to raise the sales tax to pay for the development of a new park downtown. Let’s say that 53% of the voters vote in favor of the proposition. The quantity “53%” describes the population of voters who voted in the election. A number that describes a population is called a *parameter*.

### DEFINITION

A **parameter** is a number that describes a population.

### EXPLAIN IT AGAIN

**Statistic and parameter:** An easy way to remember these terms is that “statistic” and “sample” both begin with “s,” and “parameter” and “population” both begin with “p.”

### Example 1.10

## Distinguishing between a statistic and a parameter

Which of the following is a statistic and which is a parameter?

- a. 57% of the teachers at Central High School are female.
- b. In a sample of 100 surgery patients who were given a new pain reliever, 78% of them reported significant pain relief.

### Solution

- a. The number 57% is a parameter, because it describes the entire population of teachers in the school.
- b. The number 78% is a statistic, because it describes a sample.

## Using Technology

We use Example 1.5 to illustrate the technology steps.

### TI-84 PLUS

#### Drawing a simple random sample

**Step 1.** Enter any nonzero number on the HOME screen as the seed.

**Step 2.** Press **STO >**

**Step 3.** Press **MATH**, select **PRB**, then **1: rand**, and then press **ENTER**. This enters the seed into the calculator memory. See Figure A, which uses the number 21 as the seed.

**Step 4.** Press **MATH**, select **PRB**, then **5: randInt**. Then enter **1, N, n**, where **N** is the population size and **n** is the desired sample size. In Example 1.5, we use **N = 40** and **n = 5** (Figure B).

**Step 5.** Press **ENTER**. The five values in the random sample for Example 1.5 are **27, 39, 30, 35, 17** (Figure C).

Note that when using this method, you may sometimes get a sample in which a number appears more than once. When this happens, just draw another sample.

A screenshot of a TI-84 PLUS calculator screen. The display shows the text "21-&gt;rand".

Figure A

A screenshot of a TI-84 PLUS calculator screen. The display shows the text "randInt(1,40,5)".

Figure B

A screenshot of a TI-84 PLUS calculator screen. The display shows "randInt(1,40,5)" followed by a list of numbers: "{27, 39, 30, 35, 17}".

Figure C

### MINITAB

#### Drawing a simple random sample

**Step 1.** Click **Calc**, then **Random Data**, then **Integer...**

**Step 2.** In the **Number of rows of data to generate** field, enter twice the desired sample size. For example, if the desired sample size is 10, enter 20. The reason for this is that some sample items may be repeated, and these will need to be deleted.

**Step 3.** In the **Store in column(s)** field, enter **C1**.

**Step 4.** Enter **1** for the **Minimum value** and the population size **N** for the **Maximum value**. We use **Maximum value = 40** for Example 1.5. Click **OK**.

**Step 5.** **Column C1** of the worksheet will contain a list of randomly selected numbers between **1** and **N**. If any number appears more than once in **Column C1**, delete the replicates so that the number appears only once. For Example 1.5, our random sample begins with **16, 14, 30, 28, 17, ...** (Figure D).

↓	C1
1	16
2	14
3	30
4	28
5	17
6	13
7	4
8	8
9	6
10	15
11	35
12	5

Figure D