

This International Student Edition is for use outside of the U.S.

Eleventh Edition

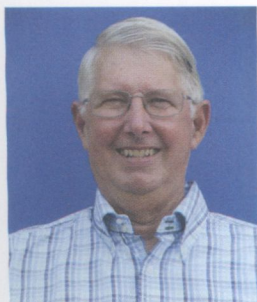
# Elementary Statistics

A STEP BY STEP APPROACH

Mc  
Graw  
Hill

ALLAN G. BLUMAN

# ABOUT THE AUTHOR



McGraw Hill

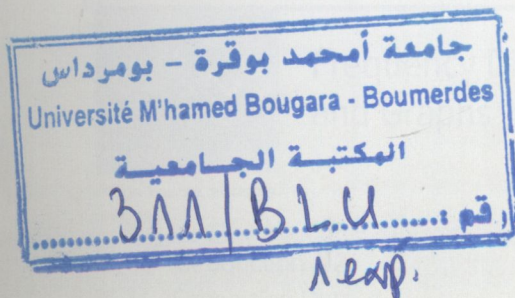
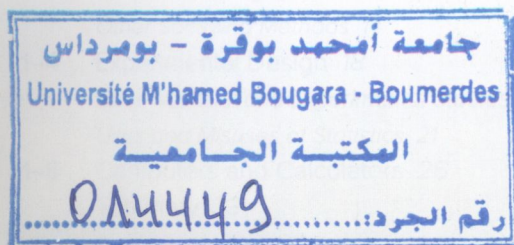
## Allan G. Bluman

Allan G. Bluman is a professor emeritus at the Community College of Allegheny County, South Campus, near Pittsburgh, Pennsylvania. He has taught mathematics and statistics for over 35 years. He received an Apple for the Teacher award in recognition of his bringing excellence to the learning environment at South Campus. He has also taught statistics for Penn State University at the Greater Allegheny (McKeesport) Campus and at the Monroeville Center. He received his master's and doctor's degrees from the University of Pittsburgh.

He is also author of *Elementary Statistics: A Brief Version* and he was a coauthor of *Math in Our World*. In addition, he is the author of four mathematics books in the McGraw Hill DeMystified Series. They are *Pre-Algebra*, *Math Word Problems*, *Business Math*, and *Probability*.

He is married and has two sons, a granddaughter, and a grandson.

**Dedication:** To Betty Bluman, Earl McPeck, and Dr. G. Bradley Seager, Jr.



# CONTENTS

Preface ix

## CHAPTER 1



Monkey Business  
Images/Shutterstock

### The Nature of Probability and Statistics 1

Introduction 2

- 1-1 Descriptive and Inferential Statistics 3
- 1-2 Variables and Types of Data 6
- 1-3 Data Collection and Sampling Techniques 11
  - Random Sampling 12
  - Systematic Sampling 12
  - Stratified Sampling 13
  - Cluster Sampling 14
  - Other Sampling Methods 14
- 1-4 Experimental Design 18
  - Observational and Experimental Studies 18
  - Uses and Misuses of Statistics 21
- 1-5 Computers and Calculators 26
- Summary 33

## CHAPTER 2



Image Source, all rights reserved.

### Frequency Distributions and Graphs 41

Introduction 42

- 2-1 Organizing Data 42
  - Categorical Frequency Distributions 43
  - Grouped Frequency Distributions 44
- 2-2 Histograms, Frequency Polygons, and Ogives 58
  - The Histogram 59
  - The Frequency Polygon 59

The Ogive 60

Relative Frequency Graphs 62

Distribution Shapes 64

### 2-3 Other Types of Graphs 76

Bar Graphs 76

Pareto Charts 79

The Time Series Graph 80

The Pie Graph 81

Dotplots 84

Stem and Leaf Plots 85

Misleading Graphs 88

Summary 102

## CHAPTER 3



©Alan Schein/Alamy  
Stock Photo

### Data Description 111

Introduction 112

### 3-1 Measures of Central Tendency 113

The Mean 113

The Median 116

The Mode 118

The Midrange 120

The Weighted Mean 121

Distribution Shapes 123

### 3-2 Measures of Variation 129

Range 131

Population Variance and Standard Deviation 131

Sample Variance and Standard Deviation 134

Variance and Standard Deviation for Grouped Data 137

Coefficient of Variation 139

Range Rule of Thumb 140

Chebyshev's Theorem 141

The Empirical (Normal) Rule 143

Linear Transformation of Data 144

### 3-3 Measures of Position 150

Standard Scores 150

All examples and exercises in this textbook (unless cited) are hypothetical and are presented to enable students to achieve a basic understanding of the statistical concepts explained. These examples and exercises should not be used in lieu of medical, psychological, or other professional advice. Neither the author nor the publisher shall be held responsible for any misuse of the information presented in this textbook.

- Percentiles 151
- Quartiles and Deciles 157
- Outliers 159
- 3-4** Exploratory Data Analysis 170
  - The Five-Number Summary and Boxplots 171
  - Summary 179

## CHAPTER 4



askhamdesign/E+/  
Getty Images

### Probability and Counting Rules 187

- Introduction 188
- 4-1** Sample Spaces and Probability 188
  - Basic Concepts 188
  - Classical Probability 191
  - Complementary Events 194
  - Empirical Probability 196
  - Law of Large Numbers 198
  - Subjective Probability 198
  - Probability and Risk Taking 198
- 4-2** The Addition Rules for Probability 203
- 4-3** The Multiplication Rules and Conditional Probability 214
  - The Multiplication Rules 214
  - Conditional Probability 219
  - Probabilities for "At Least" 222
- 4-4** Counting Rules 228
  - The Fundamental Counting Rule 228
  - Factorial Notation 231
  - Permutations 231
  - Combinations 233
- 4-5** Probability and Counting Rules 243
  - Summary 247

## CHAPTER 5



Suwit Rattiwat/Shutterstock

### Discrete Probability Distributions 257

- Introduction 258
- 5-1** Probability Distributions 258
- 5-2** Mean, Variance, Standard Deviation, and Expectation 265

- Mean 265
- Variance and Standard Deviation 267
- Expectation 269
- 5-3** The Binomial Distribution 275
- 5-4** Other Types of Distributions 289
  - The Multinomial Distribution 289
  - The Poisson Distribution 291
  - The Hypergeometric Distribution 293
  - The Geometric Distribution 295
- Summary 302

## CHAPTER 6



Fuse/Getty Images

### The Normal Distribution 309

- Introduction 310
- 6-1** Normal Distributions 310
  - The Standard Normal Distribution 313
  - Finding Areas Under the Standard Normal Distribution Curve 314
  - A Normal Distribution Curve as a Probability Distribution Curve 316
- 6-2** Applications of the Normal Distribution 326
  - Finding Data Values Given Specific Probabilities 330
  - Determining Normality 333
- 6-3** The Central Limit Theorem 343
  - Distribution of Sample Means 343
  - Finite Population Correction Factor (Optional) 349
- 6-4** The Normal Approximation to the Binomial Distribution 353
  - Summary 360

## CHAPTER 7



Fuse/Getty Images

### Confidence Intervals and Sample Size 369

- Introduction 370
- 7-1** Confidence Intervals 370
- 7-2** Confidence Intervals for the Mean When  $\sigma$  Is Known 373
  - Sample Size 377

- 7-3 Confidence Intervals for the Mean When  $\sigma$  Is Unknown 383
- 7-4 Confidence Intervals and Sample Size for Proportions 390
  - Confidence Intervals 392
  - Sample Size for Proportions 394
- 7-5 Confidence Intervals for Variances and Standard Deviations 399
  - Summary 406

## CHAPTER 8



Photosindia.Com, LLC

### Hypothesis Testing 413

- Introduction 414
- 8-1 Steps in Hypothesis Testing—Traditional Method 414
  - P-Value Method for Hypothesis Testing 425
- 8-2 z Test for a Mean 428
- 8-3 t Test for a Mean 442
- 8-4 z Test for a Proportion 453
- 8-5  $\chi^2$  Test for a Variance or Standard Deviation 462
- 8-6 Additional Topics Regarding Hypothesis Testing 475
  - Confidence Intervals and Hypothesis Testing 475
  - Type II Error and the Power of a Test 477
  - Summary 480

## CHAPTER 9



Fuse/Corbis/  
Getty Images

### Testing the Difference Between Two Means, Two Proportions, and Two Variances 489

- Introduction 490
- 9-1 Testing the Difference Between Two Parameters 490
- 9-2 Testing the Difference Between Two Means: Using the z Test 493
- 9-3 Testing the Difference Between Two Means of Independent Samples: Using the t Test 503
- 9-4 Testing the Difference Between Two Means: Dependent Samples 511

- 9-5 Testing the Difference Between Proportions 523
- 9-6 Testing the Difference Between Two Variances 532
  - Summary 544

## CHAPTER 10



Design Pics/Inc./Alamy  
Stock Photo

### Correlation and Regression 551

- Introduction 552
- 10-1 Scatter Plots and Correlation 552
  - Correlation 556
- 10-2 Regression 568
  - Line of Best Fit 568
  - Determination of the Regression Line Equation 568
- 10-3 Coefficient of Determination and Standard Error of the Estimate 586
  - Types of Variation for the Regression Model 586
  - Residual Plots 589
  - Coefficient of Determination 590
  - Standard Error of the Estimate 591
  - Prediction Interval 594
- 10-4 Multiple Regression (Optional) 597
  - The Multiple Regression Equation 598
  - Testing the Significance of R 600
  - Adjusted  $R^2$  601
  - Summary 606

## CHAPTER 11



Mitch Hrdlicka/Photodisc/  
Getty Images

### Other Chi-Square Tests 613

- Introduction 614
- 11-1 Test for Goodness of Fit 614
  - Test of Normality (Optional) 620
- 11-2 Tests Using Contingency Tables 628
  - Test for Independence 628
  - Test for Homogeneity of Proportions 634
  - Summary 645

**CHAPTER 12**

Caiaimage/Glow Images

**Analysis of Variance 651**

Introduction 652

**12-1** One-Way Analysis of Variance 652**12-2** The Scheffé Test, Tukey Test, and Bonferroni Test 666*Scheffé Test* 666*Tukey Test* 667*Bonferroni Test* 668**12-3** Two-Way Analysis of Variance 672

Summary 687

**CHAPTER 13**

Andrew Resek/McGraw Hill

**Nonparametric Statistics 697**

Introduction 698

**13-1** Advantages and Disadvantages of Nonparametric Methods 698*Advantages* 698*Disadvantages* 698*Ranking* 699**13-2** The Sign Test 701*Single-Sample Sign Test* 701*Paired-Sample Sign Test* 704**13-3** The Wilcoxon Rank Sum Test 710**13-4** The Wilcoxon Signed-Rank Test 717**13-5** The Kruskal-Wallis Test 722**13-6** The Spearman Rank Correlation Coefficient and the Runs Test 730*Rank Correlation Coefficient* 730*The Runs Test* 733

Summary 745

**CHAPTER 14**Sonja Flemming/CBS  
via Getty Images**Sampling and Simulation 753**

Introduction 754

**14-1** Common Sampling Techniques 754*Random Sampling* 755*Systematic Sampling* 757*Stratified Sampling* 759*Cluster Sampling* 761*Other Types of Sampling Techniques* 761**14-2** Surveys and Questionnaire Design 768**14-3** Simulation Techniques and the Monte Carlo Method 771*The Monte Carlo Method* 771**14-4** Big Data 778

Summary 780

**APPENDICES****A** Tables 787**B** Data Bank 813**C** Glossary 820**D** Selected Answers SA-1**E** Important Formulas E-1

Index I-1

**ADDITIONAL TOPICS**

(Available online in ALEKS 360)

Algebra Review

Writing the Research Report

Bayes' Theorem

Alternate Approach to the Standard  
Normal Distribution

Bibliography