

Blitzer



COLLEGE ALGEBRA
7th Edition

A Brief Guide to **Getting the Most** from This Book

1 Read the Book

Feature	Description	Benefit
Section-Opening Scenarios	Every section opens with a scenario presenting a unique application of algebra in your life outside the classroom.	Realizing that algebra is everywhere will help motivate your learning. (See page 106.)
Detailed Worked-Out Examples	Examples are clearly written and provide step-by-step solutions. No steps are omitted, and each step is thoroughly explained to the right of the mathematics.	The blue annotations will help you understand the solutions by providing the reason why every algebraic step is true. (See page 111.)
Applications Using Real-World Data	Interesting applications from nearly every discipline, supported by up-to-date real-world data, are included in every section.	Ever wondered how you'll use algebra? This feature will show you how algebra can solve real problems. (See page 265.)
Great Question!	Answers to students' questions offer suggestions for problem solving, point out common errors to avoid, and provide informal hints and suggestions.	By seeing common mistakes, you'll be able to avoid them. This feature should help you not to feel anxious or threatened when asking questions in class. (See page 109.)
Brief Reviews	NEW to this edition. Brief Reviews cover skills you already learned but may have forgotten.	Having these refresher boxes easily accessible will help ease anxiety about skills you may have forgotten. (See page 478.)
Achieving Success	NEW to this edition. Achieving Success boxes offer strategies for persistence and success in college mathematics courses.	Follow these suggestions to help achieve your full academic potential in college mathematics. (See page 166.)
Explanatory Voice Balloons	Voice balloons help to demystify algebra. They translate mathematical language into plain English, clarify problem-solving procedures, and present alternative ways of understanding.	Does math ever look foreign to you? This feature often translates math into everyday English. (See page 201.)
Learning Objectives	Every section begins with a list of objectives. Each objective is restated in the margin where the objective is covered.	The objectives focus your reading by emphasizing what is most important and where to find it. (See page 124.)
Technology	The screens displayed in the technology boxes show how graphing utilities verify and visualize algebraic results.	Even if you are not using a graphing utility in the course, this feature will help you understand different approaches to problem solving. (See page 110.)

2 Work the Problems

Feature	Description	Benefit
Check Point Examples	Each example is followed by a matched problem, called a Check Point, that offers you the opportunity to work a similar exercise. The answers to the Check Points are provided in the answer section.	You learn best by doing. You'll solidify your understanding of worked examples if you try a similar problem right away to be sure you understand what you've just read. (See page 288.)
Concept and Vocabulary Checks	These short-answer questions, mainly fill-in-the-blank and true/false items, assess your understanding of the definitions and concepts presented in each section.	It is difficult to learn algebra without knowing its special language. These exercises test your understanding of the vocabulary and concepts. (See page 229.)
Extensive and Varied Exercise Sets	An abundant collection of exercises is included in an Exercise Set at the end of each section. Exercises are organized within several categories. Your instructor will usually provide guidance on which exercises to work. The exercises in the first category, Practice Exercises, follow the same order as the section's worked examples.	The parallel order of the Practice Exercises lets you refer to the worked examples and use them as models for solving these problems. (See page 406.)
Practice Plus Problems	This category of exercises contains more challenging problems that often require you to combine several skills or concepts.	It is important to dig in and develop your problem-solving skills. Practice Plus Exercises provide you with ample opportunity to do so. (See page 407.)
Retaining the Concepts	NEW to this edition. Beginning with Chapter 2, each Exercise Set contains review exercises under the header "Retaining the Concepts."	These exercises improve your understanding of the topics and help maintain mastery of the material. (See page 234.)
Preview Problems	Each Exercise Set concludes with three problems to help you prepare for the next section.	These exercises let you review previously covered material that you'll need to be successful for the forthcoming section. Some of these problems will get you thinking about concepts you'll soon encounter. (See page 312.)

3

Review for Quizzes and Tests

Feature	Description	Benefit
Mid-Chapter Check Points	At approximately the midway point in the chapter, an integrated set of review exercises allows you to review the skills and concepts you learned separately over several sections.	By combining exercises from the first half of the chapter, the Mid-Chapter Check Points give a comprehensive review before you move on to the material in the remainder of the chapter. (See page 281.)
Chapter Review Grids	Each chapter contains a review chart that summarizes the definitions and concepts in every section of the chapter. Examples that illustrate these key concepts are also referenced in the chart.	Review this chart and you'll know the most important material in the chapter! (See page 454.)
Chapter Review Exercises	A comprehensive collection of review exercises for each of the chapter's sections follows the grid.	Practice makes perfect. These exercises contain the most significant problems for each of the chapter's sections. (See page 209.)
Chapter Tests	Each chapter contains a practice test with approximately 25 problems that cover the important concepts in the chapter. Take the practice test, check your answers, and then watch the Chapter Test Prep Videos to see worked-out solutions for any exercises you miss.	You can use the chapter test to determine whether you have mastered the material covered in the chapter. (See page 213.)
Chapter Test Prep Videos	These videos contain worked-out solutions to every exercise in each chapter test and can be found in MyMathLab and on YouTube.	The videos let you review any exercises you miss on the chapter test.
Objective Videos	NEW to this edition. These fresh, interactive videos walk you through the concepts from every objective of the text.	The videos provide you with active learning at your own pace.
Cumulative Review Exercises	Beginning with Chapter 2, each chapter concludes with a comprehensive collection of mixed cumulative review exercises. These exercises combine problems from previous chapters and the present chapter, providing an ongoing cumulative review.	Ever forget what you've learned? These exercises ensure that you are not forgetting anything as you move forward. (See page 461.)

COLLEGE ALGEBRA

This page intentionally left blank

COLLEGE ALGEBRA

7th
EDITION

Robert Blitzer
Miami Dade College



Director, Portfolio Management: Anne Kelly
Courseware Portfolio Manager: Dawn Murrin
Portfolio Management Administrator: Joseph Colella
Content Producer: Kathleen A. Manley
Managing Producer: Karen Wernholm
Producer: Erica Lange
Manager, Courseware QA: Mary Durnwald
Manager, Content Development: Kristina Evans
Product Marketing Manager: Jennifer Edwards
Marketing Assistant: Jennifer Myers

Executive Marketing Manager: Peggy Lucas
Marketing Assistant: Adiranna Valencia
Senior Author Support/Technology Specialist: Joe Vetere
Production Coordination: Francesca Monaco/codeMantra
Text Design and Composition: codeMantra
Illustrations: Scientific Illustrators
Photo Research and Permission Clearance: Cenveo Publisher Services
Cover Design: Studio Montage
Cover Image: Dream Master/Shutterstock

Copyright © 2018, 2014, 2010 Pearson Education, Inc. All Rights Reserved. Printed in the United States of America. This publication is protected by copyright, and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise. For information regarding permissions, request forms and the appropriate contacts within the Pearson Education Global Rights & Permissions department, please visit www.pearsoned.com/permissions/.

Acknowledgments of third-party content appear on page C1, which constitutes an extension of this copyright page.

PEARSON, ALWAYS LEARNING, and MYMATHLAB are exclusive trademarks owned by Pearson Education, Inc. or its affiliates in the U.S. and/or other countries.

Unless otherwise indicated herein, any third-party trademarks that may appear in this work are the property of their respective owners and any references to third-party trademarks, logos or other trade dress are for demonstrative or descriptive purposes only. Such references are not intended to imply any sponsorship, endorsement, authorization, or promotion of Pearson's products by the owners of such marks, or any relationship between the owner and Pearson Education, Inc. or its affiliates, authors, licensees or distributors.

Library of Congress Cataloging-in-Publication Data

Names: Blitzer, Robert.
Title: College algebra / Robert Blitzer, Miami Dade College.
Description: Seventh edition. | Hoboken, NJ : Pearson, [2018] | Includes index.
Identifiers: LCCN 2016030693 | ISBN 9780134469164
Subjects: LCSH: Algebra—Textbooks.
Classification: LCC QA152.3.B642 2018 | DDC 512.9—dc23
LC record available at <https://lccn.loc.gov/2016030693>



ISBN 13: 978-0-13-446916-4
ISBN 10: 0-13-446916-X

CONTENTS

Preface ix
To the Student xvii
About the Author xviii
Applications Index xix

P Prerequisites: Fundamental Concepts of Algebra 1

P.1 Algebraic Expressions, Mathematical Models, and Real Numbers 2
P.2 Exponents and Scientific Notation 20
P.3 Radicals and Rational Exponents 35
P.4 Polynomials 51
Mid-Chapter Check Point 63
P.5 Factoring Polynomials 64
P.6 Rational Expressions 76
Summary, Review, and Test 89
Review Exercises 90
Chapter P Test 92

1 Equations and Inequalities 93

1.1 Graphs and Graphing Utilities 94
1.2 Linear Equations and Rational Equations 106
1.3 Models and Applications 124
1.4 Complex Numbers 139
1.5 Quadratic Equations 148

Mid-Chapter Check Point 171

1.6 Other Types of Equations 173

1.7 Linear Inequalities and Absolute Value Inequalities 189

Summary, Review, and Test 206

Review Exercises 209

Chapter 1 Test 213





3 Polynomial and Rational Functions 345

- 3.1 Quadratic Functions 346
- 3.2 Polynomial Functions and Their Graphs 364
- 3.3 Dividing Polynomials; Remainder and Factor Theorems 382
- 3.4 Zeros of Polynomial Functions 395
- Mid-Chapter Check Point** 410
- 3.5 Rational Functions and Their Graphs 411
- 3.6 Polynomial and Rational Inequalities 431
- 3.7 Modeling Using Variation 444
- Summary, Review, and Test** 454
- Review Exercises** 456
- Chapter 3 Test** 460
- Cumulative Review Exercises (Chapters 1–3)** 461

2 Functions and Graphs 215

- 2.1 Basics of Functions and Their Graphs 216
- 2.2 More on Functions and Their Graphs 235
- 2.3 Linear Functions and Slope 255
- 2.4 More on Slope 271
- Mid-Chapter Check Point** 281
- 2.5 Transformations of Functions 282
- 2.6 Combinations of Functions; Composite Functions 298
- 2.7 Inverse Functions 313
- 2.8 Distance and Midpoint Formulas; Circles 325
- Summary, Review, and Test** 334
- Review Exercises** 337
- Chapter 2 Test** 341
- Cumulative Review Exercises (Chapters 1–2)** 343





4 Exponential and Logarithmic Functions 463

- 4.1 Exponential Functions 464
- 4.2 Logarithmic Functions 478
- 4.3 Properties of Logarithms 493
- Mid-Chapter Check Point** 503
- 4.4 Exponential and Logarithmic Equations 504
- 4.5 Exponential Growth and Decay; Modeling Data 519
- Summary, Review, and Test** 533
- Review Exercises** 535
- Chapter 4 Test** 539
- Cumulative Review Exercises (Chapters 1–4)** 540

5 Systems of Equations and Inequalities 541

- 5.1 Systems of Linear Equations in Two Variables 542
- 5.2 Systems of Linear Equations in Three Variables 561
- 5.3 Partial Fractions 569
- 5.4 Systems of Nonlinear Equations in Two Variables 580
- Mid-Chapter Check Point** 590
- 5.5 Systems of Inequalities 591
- 5.6 Linear Programming 603
- Summary, Review, and Test** 611
- Review Exercises** 613
- Chapter 5 Test** 616
- Cumulative Review Exercises (Chapters 1–5)** 616

6 Matrices and Determinants 619

- 6.1 Matrix Solutions to Linear Systems 620
- 6.2 Inconsistent and Dependent Systems and Their Applications 634
- 6.3 Matrix Operations and Their Applications 643
- Mid-Chapter Check Point** 658
- 6.4 Multiplicative Inverses of Matrices and Matrix Equations 659
- 6.5 Determinants and Cramer's Rule 673
- Summary, Review, and Test** 686
- Review Exercises** 687
- Chapter 6 Test** 689
- Cumulative Review Exercises (Chapters 1–6)** 690

7 Conic Sections 691

7.1 The Ellipse 692

7.2 The Hyperbola 707

Mid-Chapter Check Point 722

7.3 The Parabola 723

Summary, Review, and Test 737

Review Exercises 739

Chapter 7 Test 740

Cumulative Review Exercises (Chapters 1–7) 741

8 Sequences, Induction, and Probability 743

8.1 Sequences and Summation Notation 744

8.2 Arithmetic Sequences 755

8.3 Geometric Sequences and Series 766

Mid-Chapter Check Point 781

8.4 Mathematical Induction 782

8.5 The Binomial Theorem 791

8.6 Counting Principles, Permutations, and Combinations 799

8.7 Probability 810

Summary, Review, and Test 825

Review Exercises 827

Chapter 8 Test 830

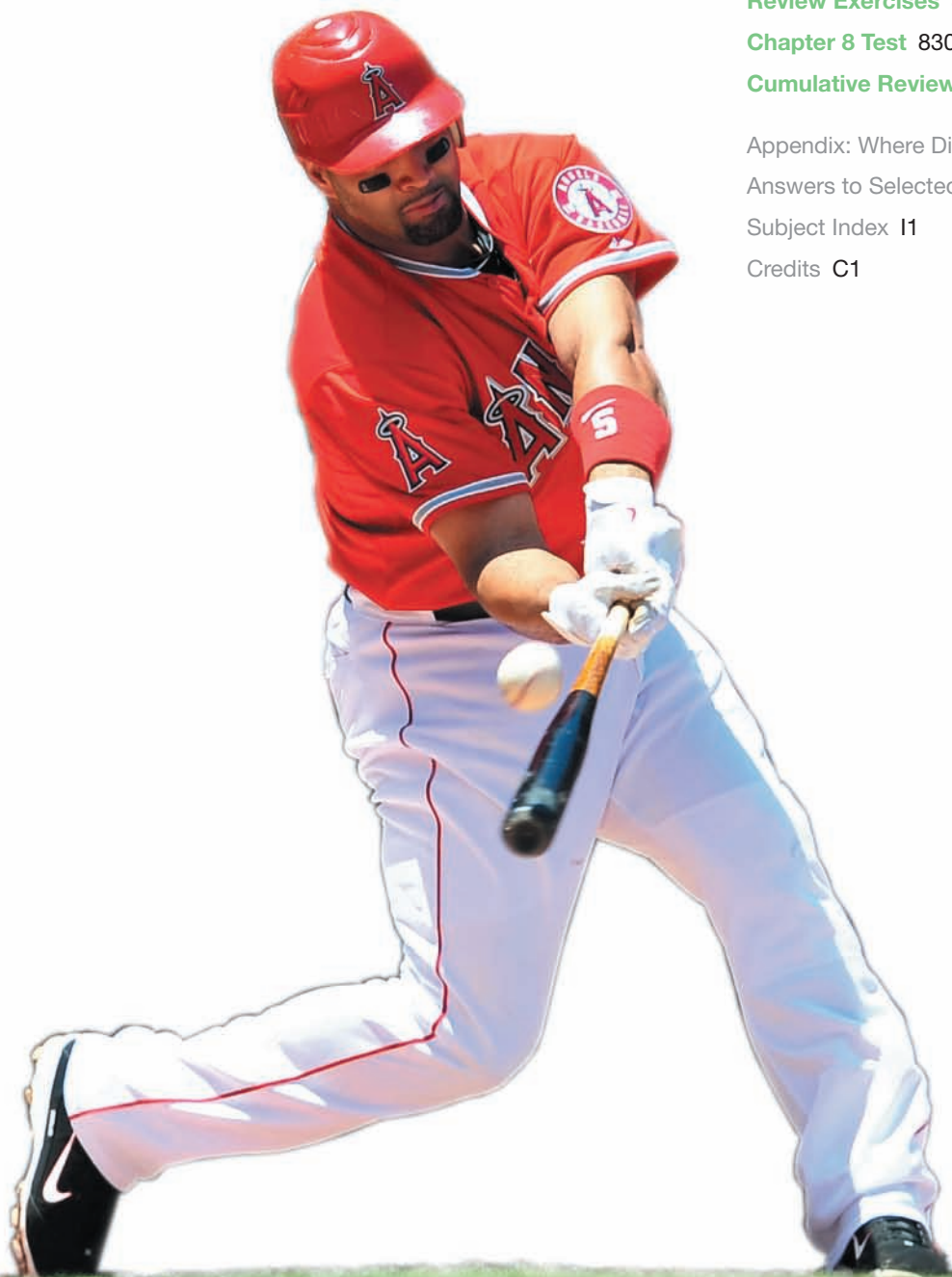
Cumulative Review Exercises (Chapters 1–8) 831

Appendix: Where Did That Come From? Selected Proofs 833

Answers to Selected Exercises AA1

Subject Index I1

Credits C1



PREFACE

I've written *College Algebra, Seventh Edition*, to help diverse students, with different backgrounds and future goals, to succeed. The book has three fundamental goals:

1. To help students acquire a solid foundation in algebra, preparing them for other courses such as calculus, business calculus, and finite mathematics.
2. To show students how algebra can model and solve authentic real-world problems.
3. To enable students to develop problem-solving skills, while fostering critical thinking, within an interesting setting.

One major obstacle in the way of achieving these goals is the fact that very few students actually read their textbook. This has been a regular source of frustration for me and for my colleagues in the classroom. Anecdotal evidence gathered over years highlights two basic reasons that students do not take advantage of their textbook:

- “I’ll never use this information.”
- “I can’t follow the explanations.”

I've written every page of the Seventh Edition with the intent of eliminating these two objections. The ideas and tools I've used to do so are described for the student in “A Brief Guide to Getting the Most from This Book,” which appears at the front of the book.

What's New in the Seventh Edition?

- **New Applications and Real-World Data.** The Seventh Edition contains 63 worked-out examples and exercises based on new data sets, and 36 examples and exercises based on data updated from the Sixth Edition. Many of the new applications involve topics relevant to college students, including student-loan debt (Chapter P, Mid-Chapter Check Point, Exercise 31), grade inflation (Exercise Set 1.2, Exercises 97–98), median earnings, by final degree earned (Exercise Set 1.3, Exercises 3–4), excuses for not meeting deadlines (Chapter 1 Summary, Exercise 36), political orientation of college freshmen (Chapter 2 Summary, Exercise 53), sleep hours of college students (Exercise Set 5.1, Exercise 74), and the number of hours college students study per week, by major (Exercise Set 5.2, Exercises 33–34).
- **Brief Reviews.** Beginning with Chapter 1, the Brief Review boxes that appear throughout the book summarize mathematical skills, many of which are course prerequisites, that students have learned, but which many students need to review. This feature appears whenever a particular skill is first needed and eliminates the need for you to reteach that skill. For more detail, students are referred to the appropriate section and objective in a previous chapter where the topic is fully developed.

- **Achieving Success.** The Achieving Success boxes, appearing at the end of many sections in Chapters 1 through 5, offer strategies for persistence and success in college mathematics courses.
- **Retaining the Concepts.** Beginning with Chapter 2, Section 2.1, each Exercise Set contains three review exercises under the header “Retaining the Concepts.” These exercises are intended for students to review previously covered objectives in order to improve their understanding of the topics and to help maintain their mastery of the material. If students are not certain how to solve a review exercise, they can turn to the section and worked example given in parentheses at the end of each exercise. The Seventh Edition contains 78 new exercises in the “Retaining the Concepts” category.
- **New Blitzer Bonus Videos with Assessment.** Many of the Blitzer Bonus features throughout the textbook have been turned into animated videos that are built into the MyMathLab course. These videos help students make visual connections to algebra and the world around them. Assignable exercises have been created within the MyMathLab course to assess conceptual understanding and mastery. These videos and exercises can be turned into a media assignment within the Blitzer MyMathLab course.
- **Updated Learning Guide.** Organized by the textbook's learning objectives, this updated Learning Guide helps students learn how to make the most of their textbook for test preparation. Projects are now included to give students an opportunity to discover and reinforce the concepts in an active learning environment and are ideal for group work in class.
- **Updated Graphing Calculator Screens.** All screens have been updated using the TI-84 Plus C.

What Content and Organizational Changes Have Been Made to the Seventh Edition?

- **Section P.1 (Algebraic Expressions, Mathematical Models, and Real Numbers)** follows an example on the cost of attending college (Example 2) with a new Blitzer Bonus, “Is College Worthwhile?”
- **Section P.6 (Rational Expressions)** uses the least common denominator to combine rational expressions with different denominators, including expressions having no common factors in their denominators.
- **Section 1.1 (Graphing and Graphing Utilities)** contains a new example of a graph with more than one x -intercept (Example 5(d)).

- **Section 1.4 (Complex Numbers)** includes a new example on dividing complex numbers where the numerator is of the form bi (Example 3). (This is then followed by an example picked up from the Sixth Edition where the numerator is of the form $a + bi$.)
- **Section 1.5 (Quadratic Equations)** provides a step-by-step procedure for solving quadratic equations by completing the square. This procedure forms the framework for the solutions in Examples 4 and 5.
- **Section 1.5 (Quadratic Equations)** contains an example on the quadratic formula (Example 6) where the formula is used to solve a quadratic equation with rational solutions, an equation that students can also solve by factoring.
- **Section 1.5 (Quadratic Equations)** has a new application of the Pythagorean Theorem (Example 11) involving HDTV screens. The example is followed by a new Blitzer Bonus, “Screen Math.”
- **Section 1.6 (Other Types of Equations)** includes an example on solving an equation quadratic in form (Example 8),

$$(x^2 - 5)^2 + 3(x^2 - 5) - 10 = 0,$$

where u is a binomial ($u = x^2 - 5$).

- **Section 2.2 (More on Functions and Their Graphs)** contains a new discussion on graphs with three forms of symmetry (Examples 2 and 3) before presenting even and odd functions. A new example (Example 4) addresses identifying even or odd functions from graphs.
- **Section 2.3 (Linear Functions and Slope)** includes a new Blitzer Bonus, “Slope and Applauding Together.”
- **Section 2.7 (Inverse Functions)** replaces an example on finding the inverse of $f(x) = \frac{5}{x} + 4$ with an example on finding the inverse of $f(x) = \frac{x + 2}{x - 3}$ (Example 4), a function with two occurrences of x .
- **Section 3.5 (Rational Functions and Their Graphs)** opens with a discussion of college students and video games. This is revisited in a new example (Example 9, “Putting the Video-Game Player Inside the Game”) involving the Oculus Rift, a virtual reality headset that enables users to experience video games as immersive three-dimensional environments.
- **Section 5.1 (Systems of Linear Equations in Two Variables)** contains a new discussion on problems involving mixtures, important for many STEM students. A new example (Example 8) illustrates the procedure for solving a mixture problem.
- **Section 6.1 (Matrix Solutions to Linear Systems)** has a new opening example (Example 1) showing the details on how to write an augmented matrix.

- **Section 7.1 (The Ellipse)** includes a new example (Example 5) showing the details on graphing an ellipse centered at (h, k) by completing the square.
- **Section 7.3 (The Parabola)** adds a new objective on identifying conics of the form $Ax^2 + Cy^2 + Dx + Ey + F = 0$ without completing the square, supported by an example (Example 7).
- **Section 8.2 (Arithmetic Sequences)** contains a new example (Example 3) on writing the general term of an arithmetic sequence.
- **Section 8.7 (Probability)** uses the popular lottery games Powerball (Example 5) and Mega Millions (Exercises 27–30) as applications of probability and combinations.

What Familiar Features Have Been Retained in the Seventh Edition?

- **Learning Objectives.** Learning objectives, framed in the context of a student question (What am I supposed to learn?), are clearly stated at the beginning of each section. These objectives help students recognize and focus on the section’s most important ideas. The objectives are restated in the margin at their point of use.
- **Chapter-Opening and Section-Opening Scenarios.** Every chapter and every section open with a scenario presenting a unique application of mathematics in students’ lives outside the classroom. These scenarios are revisited in the course of the chapter or section in an example, discussion, or exercise.
- **Innovative Applications.** A wide variety of interesting applications, supported by up-to-date, real-world data, are included in every section.
- **Detailed Worked-Out Examples.** Each example is titled, making the purpose of the example clear. Examples are clearly written and provide students with detailed step-by-step solutions. No steps are omitted and each step is thoroughly explained to the right of the mathematics.
- **Explanatory Voice Balloons.** Voice balloons are used in a variety of ways to demystify mathematics. They translate algebraic ideas into everyday English, help clarify problem-solving procedures, present alternative ways of understanding concepts, and connect problem solving to concepts students have already learned.
- **Check Point Examples.** Each example is followed by a similar matched problem, called a Check Point, offering students the opportunity to test their understanding of the example by working a similar exercise. The answers to the Check Points are provided in the answer section.

- **Concept and Vocabulary Checks.** This feature offers short-answer exercises, mainly fill-in-the-blank and true/false items, that assess students' understanding of the definitions and concepts presented in each section. The Concept and Vocabulary Checks appear as separate features preceding the Exercise Sets.
- **Extensive and Varied Exercise Sets.** An abundant collection of exercises is included in an Exercise Set at the end of each section. Exercises are organized within nine category types: Practice Exercises, Practice Plus Exercises, Application Exercises, Explaining the Concepts, Technology Exercises, Critical Thinking Exercises, Group Exercises, Retaining the Concepts, and Preview Exercises. This format makes it easy to create well-rounded homework assignments. The order of the Practice Exercises is exactly the same as the order of the section's worked examples. This parallel order enables students to refer to the titled examples and their detailed explanations to achieve success working the Practice Exercises.
- **Practice Plus Problems.** This category of exercises contains more challenging practice problems that often require students to combine several skills or concepts. With an average of ten Practice Plus problems per Exercise Set, instructors are provided with the option of creating assignments that take Practice Exercises to a more challenging level.
- **Mid-Chapter Check Points.** At approximately the midway point in each chapter, an integrated set of Review Exercises allows students to review and assimilate the skills and concepts they learned separately over several sections.
- **Graphing and Functions.** Graphing is introduced in Chapter 1 and functions are introduced in Chapter 2, with an integrated graphing functional approach emphasized throughout the book. Graphs and functions that model data appear in nearly every section and Exercise Set. Examples and exercises use graphs of functions to explore relationships between data and to provide ways of visualizing a problem's solution. Because functions are the core of this course, students are repeatedly shown how functions relate to equations and graphs.
- **Integration of Technology Using Graphic and Numerical Approaches to Problems.** Side-by-side features in the technology boxes connect algebraic solutions to graphic and numerical approaches to problems. Although the use of graphing utilities is optional, students can use the explanatory voice balloons to understand different approaches to problems even if they are not using a graphing utility in the course.
- **Great Question!** This feature presents a variety of study tips in the context of students' questions. Answers to questions offer suggestions for problem solving, point out common errors to avoid, and provide informal hints and suggestions. As a secondary benefit, this feature should help students not to feel anxious or threatened when asking questions in class.
- **Chapter Summaries.** Each chapter contains a review chart that summarizes the definitions and concepts in every section of the chapter. Examples that illustrate these key concepts are also referenced in the chart.
- **End-of-Chapter Materials.** A comprehensive collection of Review Exercises for each of the chapter's sections follows the Summary. This is followed by a Chapter Test that enables students to test their understanding of the material covered in the chapter. Beginning with Chapter 2, each chapter concludes with a comprehensive collection of mixed Cumulative Review Exercises.
- **Blitzer Bonuses.** These enrichment essays provide historical, interdisciplinary, and otherwise interesting connections to the algebra under study, showing students that math is an interesting and dynamic discipline.
- **Discovery.** Discovery boxes, found throughout the text, encourage students to further explore algebraic concepts. These explorations are optional and their omission does not interfere with the continuity of the topic under consideration.

I hope that my passion for teaching, as well as my respect for the diversity of students I have taught and learned from over the years, is apparent throughout this new edition. By connecting algebra to the whole spectrum of learning, it is my intent to show students that their world is profoundly mathematical, and indeed, π is in the sky.

Robert Blitzer

Acknowledgments

An enormous benefit of authoring a successful series is the broad-based feedback I receive from the students, dedicated users, and reviewers. Every change to this edition is the result of their thoughtful comments and suggestions. I would like to express my appreciation to all the reviewers, whose collective insights form the backbone of this revision. In particular, I would like to thank the following people for reviewing *College Algebra*, *Algebra and Trigonometry*, *Precalculus*, and *Trigonometry*.

Karol Albus, South Plains College

Kayoko Yates Barnhill, Clark College

Timothy Beaver, Isothermal Community College

Jaromir Becan, University of Texas-San Antonio

Imad Benjelloun, Delaware Valley College

Lloyd Best, Pacific Union College

David Bramlett, Jackson State University

Natasha Brewley-Corbin, Georgia Gwinnett College

Denise Brown, Collin College-Spring Creek Campus

David Britz, Raritan Valley Community College

Bill Burgin, Gaston College

Jennifer Cabaniss, Central Texas College

Jimmy Chang, St. Petersburg College

Teresa Chasing Hawk, University of South Dakota

Diana Colt, University of Minnesota-Duluth

Shannon Cornell, Amarillo College

Wendy Davidson, Georgia Perimeter College-Newton

Donna Densmore, Bossier Parish Community College

Disa Enegren, Rose State College

Keith A. Erickson, Georgia Gwinnett College

Nancy Fisher, University of Alabama

Donna Gerken, Miami Dade College

Cynthia Glickman, Community College of Southern Nevada

Sudhir Kumar Goel, Valdosta State University

Donald Gordon, Manatee Community College

David L. Gross, University of Connecticut

Jason W. Groves, South Plains College

Joel K. Haack, University of Northern Iowa

Jeremy Haefner, University of Colorado

Joyce Hague, University of Wisconsin at River Falls

Mike Hall, University of Mississippi

Mahshid Hassani, Hillsborough Community College

Tom Hayes, Montana State University

Christopher N. Hay-Jahans, University of South Dakota

Angela Heiden, St. Clair Community College

Celeste Hernandez, Richland College

Alysmarie Hodges, Eastfield College

Amanda Hood, Copiah-Lincoln Community College

Jo Beth Horney, South Plains College

Heidi Howard, Florida State College at Jacksonville-South Campus

Winfield A. Ihlow, SUNY College at Oswego

Nancy Raye Johnson, Manatee Community College

Dennine Larue, Fairmont State University

Mary Leesburg, Manatee Community College

Christine Heinecke Lehman, Purdue University North Central

Alexander Levichev, Boston University

Zongzhu Lin, Kansas State University

Benjamin Marlin, Northwestern Oklahoma State University

Marilyn Massey, Collin County Community College

Yvelyne McCarthy-Germaine, University of New Orleans

David McMann, Eastfield College

Owen Mertens, Missouri State University-Springfield

James Miller, West Virginia University

Martha Nega, Georgia Perimeter College-Decatur

Shahla Peterman, University of Missouri-St. Louis

Debra A. Pharo, Northwestern Michigan College

Gloria Phoenix, North Carolina Agricultural and Technical State University

Katherine Pinzon, Georgia Gwinnett College

David Platt, Front Range Community College

Juha Pohjanpelto, Oregon State University

Brooke Quinlan, Hillsborough Community College

Janice Rech, University of Nebraska at Omaha

Joseph W. Rody, Arizona State University

Behnaz Rouhani, Georgia Perimeter College-Dunwoody

Judith Salmon, Fitchburg State University

Michael Schramm, Indian River State College

Cynthia Schultz, Illinois Valley Community College

Pat Shelton, North Carolina Agricultural and Technical State University

Jed Soifer, Atlantic Cape Community College

Caroline Spillman, Georgia Perimeter College-Clarkston

Jonathan Stadler, Capital University

Franotis R. Stallworth, Gwinnett Technical College

John David Stark, Central Alabama Community College

Chris Stump, Bethel College

Scott Sykes, University of West Georgia

Richard Townsend, North Carolina Central University

Pamela Trim, Southwest Tennessee Community College

Chris Turner, Arkansas State University

*Richard E. Van Lommel, California State
University-Sacramento*

Dan Van Peursem, University of South Dakota

Philip Van Veldhuizen, University of Nevada at Reno

Jeffrey Weaver, Baton Rouge Community College

Amanda Wheeler, Amarillo College

David White, The Victoria College

Tracy Wienckowski, University of Buffalo

Additional acknowledgments are extended to Dan Miller and Kelly Barber for preparing the solutions manuals; Brad Davis for preparing the answer section, serving

as accuracy checker, and writing the new learning guide; the codeMantra formatting team for the book's brilliant paging; Brian Morris and Kevin Morris at Scientific Illustrators for superbly illustrating the book; Francesca Monaco, project manager; and Kathleen Manley, production editor, whose collective talents kept every aspect of this complex project moving through its many stages.

I would like to thank my editor at Pearson, Dawn Murrin, who, with the assistance of Joseph Colella, guided and coordinated the book from manuscript through production. Finally, thanks to Peggy Lucas and Jennifer Edwards for their innovative marketing efforts and to the entire Pearson sales force for their confidence and enthusiasm about the book.

Robert Blitzer



Get the Most Out of MyMathLab[®]

MyMathLab is the leading online homework, tutorial, and assessment program for teaching and learning mathematics, built around Pearson's best-selling content. MyMathLab helps students and instructors improve results; it provides engaging experiences and personalized learning for each student so learning can happen in any environment. Plus, it offers flexible and time-saving course management features to allow instructors to easily manage their classes while remaining in complete control, regardless of course format.

Preparedness

MyMathLab course solutions offer a complete College Algebra or Precalculus course with integrated review of select topics from developmental algebra. These courses help remediate students "just-in-time" and help with student retention of important concepts, ultimately boosting student success.

- Students begin each chapter by completing a Skills Check assignment to pinpoint which developmental topics, if any, they need to review.
- Students who demonstrate mastery of the review topics will move straight into the College Algebra content.
- A personalized review homework assignment will provide extra support for the students who need it.
- Additional review materials (worksheets, videos, and more) are available in an Integrated Review section at the start of each chapter in MyMathLab.

MyMathLab with Integrated Review are appropriate for students who struggle with pre-requisite skills and for co-requisite course models. These Integrated Review MyMathLab courses are available for a variety of College Algebra and Precalculus programs, as well as a variety of other disciplines.

Used by more than 37 million students worldwide, MyMathLab delivers consistent, measurable gains in student learning outcomes, retention, and subsequent course success.

www.mymathlab.com



Pearson

MyMathLab Online Course for College Algebra by Robert Blitzer



(access code required)

NEW! Video Program

These fresh, interactive videos walk you through the concepts from every objective of the text. The videos provide an active learning environment where students can work at their own pace.

Your Turn!
Choose the option that best answers the question.

Perform the indicated operation, writing the result in standard form:

$$(-4 - 8i) - (-7 + 2i)$$

a. $-3 - 10i$
b. $-11 - 6i$
c. $-11 + 6i$

$(x - h)^2 + (y - k)^2 = r^2$

Equations of Circles $(x - h)^2 + (y - k)^2 = r^2$

Radius:

Show Equation
 Expanded Form
 Integer Values
 Zoom Out
 Show Intercepts

Getting Started

Using slider change the Radius of the circle and determine the equation of the circle and the intercepts. Check the Show Equation and Show Intercepts boxes to check your work. The circle can be moved around by clicking and dragging to change the location.

$(x - 2)^2 + (y - 1)^2 = 9$

NEW! Guided Visualizations

These HTML-based, interactive figures help students visualize the concepts through directed explorations and purposeful manipulation. They encourage active learning, critical thinking, and conceptual learning. They are compatible with iPad and tablet devices.

The Guided Visualizations are located in the Multimedia Library and can be assigned as homework with correlating assessment exercises. Additional Exploratory Exercises are available to help students think more conceptually about the figures and provide an excellent framework for group projects or lecture discussion.

NEW! Workspace Assignments

Students can now show their work like never before! Workspace Assignments allow students to work through an exercise step-by-step, and show their mathematical reasoning as they progress. Students receive immediate feedback after they complete each step, and helpful hints and videos offer guidance when they need it. When accessed via a mobile device, Workspace exercises use handwriting recognition software that allows students to naturally write out their answers. Each student's work is automatically graded and captured in the MyMathLab gradebook so instructors can easily pinpoint exactly where they need to focus their instruction.

9.4 Complex Solutions of Quadratic Equations - Addition and Subtraction of Co...

1. Evaluate $(6 + 7i) + (4 - 9i)$.

$= (6 + (7 \times i)) + (4 - (9 \times i))$

Enter your next step here

$10 - 2i$



Resources for Success

Instructor Resources

Additional resources can be downloaded from www.mymathlab.com or www.pearsonhighered.com or hardcopy resources can be ordered from your sales representative.

Annotated Instructor's Edition

Shorter answers are on the page beside the exercises. Longer answers are in the back of the text.

Instructor's Solutions Manual

Fully worked solutions to all textbook exercises.

PowerPoint® Lecture Slides

Fully editable lecture slides that correlate to the textbook.

Mini Lecture Notes

Additional examples and helpful teaching tips for each section.

TestGen®

Enables instructors to build, edit, print, and administer tests using a computerized bank of algorithmic questions developed to cover all the objectives of the text.

Student Resources

Additional resources to help student success are available to be packaged with the Blitzer textbook and MyMathLab access code.

Objective Level Videos

These fresh, interactive videos walk students through the concepts from every objective of the text. The videos provide an active learning environment where students can work at their own pace.

Chapter Test Prep Videos

Students can watch instructors work through step-by-step solutions to all the Chapter Test exercises from the textbook. These are available in MyMathLab and on YouTube.



Student Solutions Manual

Fully worked solutions to odd-numbered exercises and available to be packaged with the textbook.

Learning Guide

This note-taking guide is organized by objective and begins each chapter with an engaging application, providing additional examples and exercises for students to work through for a greater conceptual understanding and mastery of mathematical topics. New to this edition: classroom projects are included with each chapter providing students the opportunity to work collaboratively for stronger conceptual understanding. The Learning Guide is available in PDF and customizable Word file formats in MyMathLab. It can also be packaged with the textbook and MyMathLab access code.

MathTalk Videos

Engaging videos connect mathematics to real-life events and interesting applications. These fun, instructional videos show students that math is relevant to their daily lives and are assignable in MyMathLab. Assignable exercises are available in MyMathLab for these videos to help students retain valuable information presented in the videos.

TO THE STUDENT

The bar graph shows some of the qualities that students say make a great teacher. It was my goal to incorporate each of these qualities throughout the pages of this book.

Explains Things Clearly

I understand that your primary purpose in reading *College Algebra* is to acquire a solid understanding of the required topics in your algebra course. In order to achieve this goal, I've carefully explained each topic. Important definitions and procedures are set off in boxes, and worked-out examples that present solutions in a step-by-step manner appear in every section. Each example is followed by a similar matched problem, called a Check Point, for you to try so that you can actively participate in the learning process as you read the book. (Answers to all Check Points appear in the back of the book.)

Funny & Entertaining

Who says that an algebra textbook can't be entertaining? From our unusual cover to the photos in the chapter and section openers, prepare to expect the unexpected. I hope some of the book's enrichment essays, called Blitzer Bonuses, will put a smile on your face from time to time.

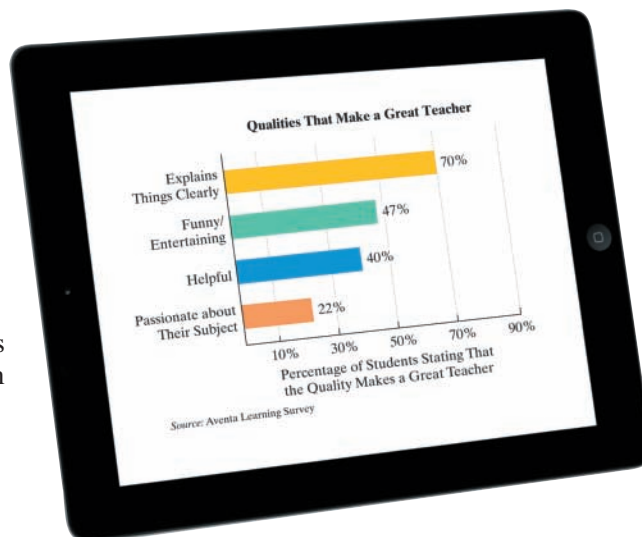
Helpful

I designed the book's features to help you acquire knowledge of college algebra, as well as to show you how algebra can solve authentic problems that apply to your life. These helpful features include:

- **Explanatory Voice Balloons:** Voice balloons are used in a variety of ways to make math less intimidating. They translate algebraic language into everyday English, help clarify problem-solving procedures, present alternative ways of understanding concepts, and connect new concepts to concepts you have already learned.
- **Great Question!:** The book's Great Question! boxes are based on questions students ask in class. The answers to these questions give suggestions for problem solving, point out common errors to avoid, and provide informal hints and suggestions.
- **Achieving Success:** The book's Achieving Success boxes give you helpful strategies for success in learning algebra, as well as suggestions that can be applied for achieving your full academic potential in future college coursework.
- **Chapter Summaries:** Each chapter contains a review chart that summarizes the definitions and concepts in every section of the chapter. Examples from the chapter that illustrate these key concepts are also referenced in the chart. Review these summaries and you'll know the most important material in the chapter!

Passionate about the Subject

I passionately believe that no other discipline comes close to math in offering a more extensive set of tools for application and development of your mind. I wrote the book in Point Reyes National Seashore, 40 miles north of San Francisco. The park consists of 75,000 acres with miles of pristine surf-washed beaches, forested ridges, and bays bordered by white cliffs. It was my hope to convey the beauty and excitement of mathematics using nature's unspoiled beauty as a source of inspiration and creativity. Enjoy the pages that follow as you empower yourself with the algebra needed to succeed in college, your career, and your life.

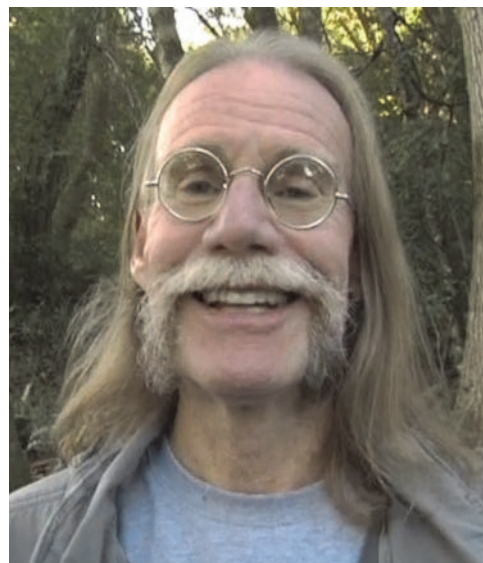


Regards,

Bob
Robert Blitzer

ABOUT THE AUTHOR

Bob Blitzer is a native of Manhattan and received a Bachelor of Arts degree with dual majors in mathematics and psychology (minor: English literature) from the City College of New York. His unusual combination of academic interests led him toward a Master of Arts in mathematics from the University of Miami and a doctorate in behavioral sciences from Nova University. Bob's love for teaching mathematics was nourished for nearly 30 years at Miami Dade College, where he received numerous teaching awards, including Innovator of the Year from the League for Innovations in the Community College and an endowed chair based on excellence in the classroom. In addition to *College Algebra*, Bob has written textbooks covering developmental mathematics, introductory algebra, intermediate algebra, trigonometry, algebra and trigonometry, precalculus, and liberal arts mathematics, all published by Pearson. When not secluded in his Northern California writer's cabin, Bob can be found hiking the beaches and trails of Point Reyes National Seashore and tending to the chores required by his beloved entourage of horses, chickens, and irritable roosters.



APPLICATIONS INDEX

- A**
- Accidents, automobile
age of driver and, 169, 689
alcohol use and, 511–512, 517, 825
- Acid rain, 517
- Actor selection, 808, 829
- Adulthood, transition to, 657
- Adult residential community costs, 755, 762
- Advertising
online spending, 832
sales and price and, 449–450, 454
- African Americans
cigarette consumption, 613
percentage with high school diploma, 538
- African life span, AIDS and, 568
- Age(s)
accidents per day and, 689
arrests and drunk driving as function of, 430
average number of awakenings during night by, 104
body-mass index and, 602
calories needed to maintain energy by, 88
chances of surviving to various, 233
fatal crashes and, 169
height as function of, 275, 278, 296
marriage and, 100–101, 138, 339
perceived length of time period and, 453
percentage of U.S. population never married, ages 25–29, 268, 270
percent body fat in adults by, 253
preferred age in a mate, 322–323
racial prejudice and, 61–62
systolic blood pressure and, 163–164
weight of human fetus and, 211
- Aging rate, space travel and, 35, 47, 50
- AIDS. *See also* HIV infection
African life span and, 568
cases diagnosed (U.S.), 364–366, 368
- Airplanes
line up for departure on runway, 829
weight/volume constraints, 605
- Alcohol use
and accident risk, 511–512, 517, 825
drunk driving arrests, 430
moderate wine consumption and heart disease, 269–270
number of moderate users in U.S., 538
by U.S. high school seniors, 104
- Alligator(s)
population of, 172
tail length given body length, 452
- Altitude and atmospheric pressure, 537
- Amazon deforestation, 457
- American Idol, ratings of, 362
- Annuities, 772–774, 779, 829
- Apogee/perigee of satellite's orbit, 706
- Applause, decibel level of, 257
- Arch bridge, 730, 739
- Archer's arrow, path of, 356
- Architecture, conic sections in, 707, 717
- Archway
parabolic, and boat clearance, 736
semi-elliptical, truck clearance under, 702–703, 705, 722, 739
- Area
maximum, 358, 361, 410, 457
of plane figure, 63
of shaded region, 62, 75
of triangle, 684
- Area code possibilities, 807
- Arrests, drunk driving, 430
- Artists in documentary, 803–804
- Aspirin, half-life of, 530, 722
- Asteroid detection, 580
- Atmospheric pressure and altitude, 537
- Automobiles
accidents per day, age of driver and, 689
alcohol use and accident risk, 511–512, 517, 825
annual price increases of, 136
average age, on U.S. roads, 136
depreciation, 136, 233
drunk driving arrests as function of age, 430
fatal accidents and driver's age, 169
possible race finishes, 808
purchase options, 807
rentals, 189–190, 200–201, 212, 430
repair estimates for, 205
required stopping distance, 431, 441–442
stopping distances, 431, 441–442
traffic control, 634, 638–643, 688
value over time, 754
- Average cost function, 424–425, 428, 458, 461
- Average rate of change, 275–276, 296
- B**
- Ball, thrown upward and outward, 361
- Ball's height above ground
baseball, 540
bounce height, 452
football, 17, 354–355, 456, 632
maximum height, 456
when thrown across field, 569
when thrown from rooftop, 441, 567
when thrown from top of building, 832
when thrown from top of Leaning Tower of Pisa, 439
when thrown straight up, 632
- Bank and credit union charges, 205
- Banking angle and turning radius of bicycle, 452
- Baseball
contract, 743, 778
diamond diagonal length, 169
height of ball above ground, 540
Little League team batting order, 801–802
- Basketball, hang time in air when shooting, 187
- Basketball court, dimensions of, 133
- Bass in lake over time, 458
- Beauty
changes in cultural values of, 541
symmetry and, 238
- Benefit concert lineup possibilities, 808
- Berlin Airlift, 603, 610
- Bias, Implicit Association Test for, 51, 61–62
- Bicycle
banking angle, 452
manufacturing, 233, 428, 556, 610
- Bird species population decline, 530
- Birth(s), in U.S. from 2000 through 2009, 298, 303–304
- Birthday, probability of sharing same, 323, 825
- Birthday cake, 51
- Blood-alcohol concentration, 15–16, 19, 511–512, 517
- Blood pressure, systolic, age and, 163–164
- Blood volume and body weight, 445–446
- Body fat in adults by age and gender, percent, 253
- Body-mass index, 452, 602
- Book club selections, 808
- Books, arranging on shelf, 803
- Book selections, 808, 831
- Bottled water, U.S. per capita consumption, 558
- Bouquet, mixture of flowers in, 590
- Box dimensions, 393
- Brain, growth of the human, 525
- Break-even analysis, 550–551, 556, 590
- Breast cancer, mammography screening data for, 811–812
- Bribery (Corruption Perceptions Index), 232
- Bridge coupon book/toll passes, 128–129, 136, 172, 205, 312
- Budgeting, groceries vs. health care, 279
- Building's shadow, 212
- Bus fares, 136
- Business ventures, 556
- C**
- Cable lengths between vertical poles, 188
- Cable service, 742
- Calculator manufacturing costs, 458
- Call of Duty* video game, retail sales of, 518
- Calorie-nutrient information, 614
- Calories
needed by age groups and activity levels, 657
needed to maintain energy balance, 88
- Camera, price before reduction, 129–130, 825
- Canoe manufacturing, 556
- Car(s). *See* Automobiles
- Carbon-14 dating, 522, 529–530
- Carbon dioxide, atmospheric global warming and, 215, 264–266
- Cardboard length/width for box, 589
- Cards. *See* Deck of 52 cards, probability and
- Cave paintings, prehistoric, 530
- CD selection for vacation trip, 829
- Celebrity earnings, 216–219
- Cellular phones
pricing of plans, 210, 234, 643
replacement of land lines with, 557
- Celsius/Fahrenheit temperature interconversions, 17, 204
- Centrifugal force, 450–451
- Checking accounts, 205
- Chernobyl nuclear power plant accident, 475
- Chess moves, 800
- Chess tournament, round-robin, 168
- Children's height modeled, 485, 491, 513
- Cholesterol
and dietary restrictions, 601
intake, 601
- Cigarette consumption. *See* Smoking

xx Applications Index

- Citizenship, number of Americans renouncing, 753
- Class structure of the United States, 687–688
- Club officers, choosing, 808, 829
- Coding, 659, 668–669, 671, 672
- Coffee consumption, sleep and, 540
- Coin tosses, 204, 813, 820, 822, 824
- College(s)
- attendance, 829
 - average dormitory charges at, 764–765
 - percentage of U.S. high school seniors applying to more than three, 476
 - projected enrollment, 136, 211
 - salary after, 209
- College assignments, excuses for not meeting deadlines, 210
- College education
- availability of, to qualified students, 136
 - average yearly earnings and, 135–136
 - cost of, 2, 4–5, 19
 - excuses for not meeting assignment deadlines, 210
 - government aid decreases, 211
 - women *vs.* men, 92
- College graduates
- among people ages 25 and older, in U.S., 476
 - median starting salaries for, 125–126
 - percentage among Americans ages 25 and older, 764
- College majors, campus mergers and, 138
- College students
- excuses for not meeting assignment deadlines, 210
 - freshmen
 - attitudes about life goals, 126–127
 - claiming no religious affiliation, 217–218, 220
 - grade inflation, 121–122
 - political orientation, 339
 - hours per week spent studying, by major, 567–568
 - loan debt, 63
 - music majors, 559
 - percentage students playing online games, 559
 - procrastination and symptoms of physical illness among, 542, 557
 - sleep hours of, 559
 - study abroad destinations, 722
 - women as percentage of, 559
- College tuition
- government aid decreases, 211
 - student loan debt, 63
- Collinear points, 684
- Comedians, net worth of, 492
- Comedy act schedule, 808
- Comets
- Halley's Comet, 702, 717, 730
 - intersection of planet paths and, 588, 717
- Committee formation, 804, 806, 808
- Commuters, toll discount passes, 128–129, 136, 172, 205, 312
- Compound interest
- annuity, 772–774, 779
 - choosing between investments, 473
 - compounding periods, 477
 - continuously compounded, 504, 512, 516, 538, 539, 617
 - formula for, 512
 - investments, 535
 - IRA, 779, 829
 - savings accounts, 515–517
 - sequences for, 754
 - value of Manhattan Island and, 476
- Computer(s)
- assembly, time required for, 459
 - computer-generated animation, 282
 - discounts, 304–305, 312
 - PC *vs.* tablet sales, 537
 - price before reduction, 130, 533
 - prices, 314, 616
 - ratio of students to computers in U.S. public schools, 368
 - sale price, 75
- Computer graphics, 619, 643, 652, 653
- Concentration of mixture, 122
- Concerts, ticket price increase, 828
- Cone volume, 451
- Conference attendees, choosing, 806, 808
- Continuously compounded interest, 504, 512, 516, 538, 539, 617
- Cookies, supply and demand for, 557
- Coronary heart disease, 531
- Corporate income tax, 172
- Corporation officers, choosing, 802–803, 808
- Corruption Perceptions Index, 232
- Cost(s). *See also* Manufacturing costs
- of college education, 2, 4–5, 19
 - minimizing, 610
 - of raising child born in U.S., 748–749
- Cost and revenue functions/ breakeven points, 556, 616
- average, 424–425, 428, 458, 461
 - bike manufacturing, 428
 - computer desk manufacturing, 613
 - graphing calculator manufacturing, 458
 - PDA manufacturing, 590
 - radio manufacturing, 311
 - roast beef sandwiches, 362
 - running shoe manufacturing, 428, 551
 - virtual reality headset manufacturing, 424–425
 - wheelchair manufacturing, 425, 550–552
- Course schedule, options in planning, 800
- Crime
- decrease in violent, 270
 - mandatory minimum sentences, 558
 - prison population and, 589
- Cryptograms, 668–669, 672. *See also* Coding
- ### D
- Data plan, 643
- Deadlines, excuses for not meeting, 210
- Dead Sea Scrolls, carbon-14 dating of, 522
- Death penalty, sentences rendered by U.S. juries, 381
- Death rate, hours of sleep and, 561, 565
- Deaths
- in the 20th century, 614
 - from 2000 through 2009, 298, 303–304
 - by snakes, mosquitoes, and snails, 234
- Debt
- national, 20, 31–32, 34, 35, 91
 - student loan, 63
- Decay model for carbon-14, 529–530
- Decibels. *See* Sound intensity
- Deck of 52 cards, probability and, 814–815, 817–818, 822, 823, 830, 831
- Decoding a word or message, 669, 671, 672
- Deforestation, Amazon, 457
- Degree-days, 765
- Depreciation, 136, 233
- Depression
- exercise and, 282
 - sense of humor and, 106–107, 118–119
 - in smokers *vs.* non-smokers, 796–797
- Desk manufacturing, 632
- Die rolling outcomes, 813–814, 823, 824, 829
- Digital media, hours per day spent on, 753
- Digital photography, 643, 652–653, 656, 658, 688
- Dinosaur bones, potassium-40 dating of, 530
- Distance
- between houses at closest point, 720
 - between pairs of cities, 333
 - safe, expressway speed and, 90
 - of ship from radio towers on coast, 720, 739
- Distance traveled
- by car after brakes applied, 567
 - combined walking and bus travel, 19
 - by skydiver, 781
- Diver's height above water, 441
- Diversity index, 90
- Divorce, age of wife at marriage and probability of, 100–101
- Documentary, selecting artists for, 803–804
- “Don't ask, don't tell” policy, 279–280
- Dormitory charges, 764–765
- Drink order possibilities, 807
- Drivers, age of. *See under* Age(s)
- Driving accident while intoxicated, probability of, 825
- Driving rate and time for trip, 447
- Drug concentration, 277, 428
- Drug experiment volunteer selection, 807, 808
- Drug offenses, mandatory minimum sentences, 558
- Drug tests, mandatory, probability of accurate results, 824
- Drug use among teenagers, 531
- Drunk driving arrests, age as function of, 430
- Dual investments, 19, 130–131, 137, 172, 211, 254, 343, 454, 601, 617
- ### E
- Eagle, height and time in flight, 338
- Earnings. *See Salary(-ies)*
- Earth, age of, 28
- Earthquake
- epicenter, 333
 - intensity, 478, 486, 536
- Earthquake relief, 603–606
- Economic impact of factory on town, 780, 829
- Education. *See also* College education
- level of, U.S. population, 764, 823
 - percentage of U.S. adults completing high school, 538
 - unemployment and years of, 459
- Election ballot, 808
- Electrical resistance, 147, 453, 832
- Elephant's weight, 517
- Elevator capacity, 205, 601
- Elk population, 540
- Elliptical ceiling, 705
- Ellipticpool, 705, 739
- Encoding a message, 659, 668–669, 671, 672
- Endangered species, 530
- Ethnic diversity, 90
- Exam grades, 205, 212, 657
- Excuses, for not meeting college assignment deadlines, 210
- Exercise
- depression and, 282
 - heart rate and, 3
 - target heart rate ranges for, 18
- Explosion recorded by two microphones, location of, 717–718, 720, 722

- Exponential decay model, 530, 538, 539, 690, 722
- Expressway speeds and safe distances, 90
- Eye color and gender, 831
- F**
- Factory, economic impact on town, 780, 829
- Fahrenheit/Celsius temperature interconversions, 17, 204
- Family, independent events in, 821, 823, 830
- Federal budget
deficit, 91 (*See also* National debt)
expenditures on human resources, 429
- Federal Express aircraft purchase decisions, 610
- Federal income tax, 234
- Federal prison population, mandatory minimum sentences and, 558
- Fencing
for enclosure, 585–586
maximum area inside, 358, 361, 363
- Ferris wheel, 333
- Fetal weight, age and, 211
- Field's dimensions, 615, 832
- Films, Oscar-winning, 313
- Financial aid, college student, 211
- Flashlight using parabolic reflecting mirror, 731–732, 735
- Flood, probability of, 830
- Floor dimensions, and area for pool and fountain, 588
- Floor space, length and width of, 212
- Flu
epidemic, 523–524
inoculation costs, 88
outbreak on campus, 780
time-temperature scenario, 235–236
vaccine mixture, 233, 552–554
- Food
cost per item, 279, 568
lunch menus, 610, 807
nutritional content, 632, 642
- Football field dimensions, 132–133
- Football game broadcasts, time devoted to game action, 817
- Football's height above ground, 17, 354–355, 632
- Foreign-born population in U.S., 172
- FoxTrot* comic strip, 49
- Frame dimensions, 137
- Freedom 7* spacecraft flight, 324
- Free-falling object's position, 438–439, 441, 459, 832
- Frequency, length of violin string and, 449
- Freshmen. *See under* College students
- Fuel efficiency, 235
- G**
- Galaxies, elliptical, 791
- Garbage, daily per-pound production of, 63
- Garden, width of path around, 170
- Gasoline price
average U.S. price, 380
supply/demand and, 556–557
- Gas pressure in can, 448
- Gay marriage, U.S. public opinion on, 531, 558
- Gay service members discharged from military, 279–280
- Gender
average number of awakenings during night by, 104
bachelor's degrees awarded and, 92
calories needed to maintain energy by, 88
eye color and, 831
first-year U.S. college students claiming no religious affiliation by, 217–218, 220
housework and, 491
labor force participation by, 187
life expectancy by year of birth and, 268
percentage of United States population never married, ages 25–29 and, 268, 270
percent body fat in adults by, 253
wage gap by, 233
and workforce participation, 620
- George Washington Bridge, 740
- Global warming, 215, 264–266
- Golden Gate Bridge, 736
- Golden rectangles, 50
- Government financial aid, college tuition, 211
- Grade inflation, 121–122
- Gravitational force, 450
- Gravity model, 453
- Groceries, budgeting for, 279
- Gutter cross-sectional area, 170, 361
- H**
- Half-life
aspirin, 530, 722
radioactive elements, 530, 538, 690
Xanax, 530
- Halley's Comet, 702, 717, 730
- Hamachiphobia, 531
- Happiness
average level of, at different times of day, 323
per capita income and national, 269
- HDTV screen dimensions, 164–165, 443
- Headlight unit design, 731, 740, 741
- Health care
budgeting for, 279
gross domestic product (GDP) spent on, 516
savings needed for expenses during retirement, 531
- Health club membership fees, 136
- Heart beats over lifetime, 35
- Heart disease
coronary, 531
moderate wine consumption and, 269–270
smoking and, 430
- Heart rate
exercise and, 3, 18
life span and, 460
before and during panic attack, 380
- Heat generated by stove, 453
- Heat loss of a glass window, 453
- Height. *See also* Ball's height
above ground of building, shadow cast and, 212
child's height modeled, 485, 491, 513
diver's height above water, 441
of eagle, in terms of time in flight, 338
as function of age, 275, 278, 296
healthy weight region for, 541, 595–596, 601–602
maximum, 832
percentage of adult height attained by girl of given age, 491, 513
weight and height recommendations/calculations, 137, 452
- High school education, percentage of U.S. adults completing, 538
- Hispanic Americans
cigarette consumption, 613
population growth, 538
- HIV infection. *See also* AIDS
number of Americans living with, 364
T cell count and, 216, 225–226
- Hotel room types, 559
- Households, mixed religious beliefs in, 204
- House sales prices, 234, 781
- House value, inflation rate and, 476
- Housework, weekly hours of, 491
- Hubble Space Telescope, 454, 723, 731, 732
- Human resources, federal budget expenditures on, 429
- Humor, sense of, depression and, 106–107, 118–119
- Hurricanes
barometric air pressure and, 517
probability of, 824
- Hydrogen ion concentration, 516–517
- I**
- Ice cream flavor combinations, 804, 808
- Identical twins, distinguishing between, 560
- Illumination intensity, 452, 453
- Imaginary number joke, 147
- Implicit Association Test, 51, 61–62
- Income
highest paid TV celebrities, 216–219
length of time to earn \$1000, 124
- Income tax, federal, 234
- Individual Retirement Account (IRA), 772–774, 779, 780, 829
- Inflation, cost of, 122
- Inflation rate, 476
- Influenza. *See* Flu
- Inn charges, before tax, 137
- Inoculation costs for flu, 88
- Insurance, pet, 253
- Intelligence quotient (IQ) and mental/chronological age, 452
- Interracial marriage, percentage of Americans in favor of laws prohibiting, 212
- Investment(s)
accumulated value of, 471–473, 475, 512
amounts invested per rate, 568
choosing between, 473
compound interest, 471–473, 475–477, 504, 512, 516, 517, 535, 538, 539, 617, 779
for desired return, 212
dual, 19, 130–131, 137, 172, 211, 254, 343, 454, 601, 617
in greeting cards, 556
and interest rates, 19
maximizing expected returns, 611
money divided between high- and low-risk, 601
in play, 556
possibility of stock price changes, 829
- IQ (intelligence quotient) and mental/chronological age, 452
- IRA. *See* Individual Retirement Account
- J**
- Jeans, price of, 312
- Jet skis, 616
- Job applicants, filling positions with, 830
- Job offers, 765, 766, 778
- Jokes about books, 809
- K**
- Kidney stone disintegration, 702, 722
- Kinetic energy, 453
- L**
- Labor force, participation by gender, 187
- Labrador retrievers, color of, 60
- Ladder's reach, 169
- Land line telephones, replacement with cell phones, 557
- Lead, half-life of, 530
- Learning curve, 122

- Learning theory project, 524
Lemon tree, maximum yield, 363
Length of violin string and frequency, 449
Letter arrangements, 808
License plates, 801
Life, most time-consuming activities during, 135
Life events, sense of humor and response to, 106–107, 118–119
Life expectancy, 135, 268
Life span, heart rate and, 460
Light intensity, 461, 515
Light reflectance and parabolic surface, 731, 740
Line formation, 809
Literacy and child mortality, 255, 269
Little League baseball team batting order, 801–802
Living alone, number of Americans, 271, 274–275, 342
Long-distance telephone charges, 137
Lottery
 numbers selection, 808
 probability of winning, 799, 815–816, 823, 824, 830, 831
LOTTO, numbers selection for, 808
Loudness, 257, 453, 459, 491, 502, 531, 539
Love, course of over time, 204
Luggage, volume of carry-on, 407–408
Lunch menus, 610, 807
- M**
Mailing costs, 253
Mall browsing time and average amount spent, 464, 465
Mammography screening data, 811–812
Mandatory drug testing, probability of accurate results, 824
Manufacturing and testing, hours needed for, 642
Manufacturing constraints, 604, 606, 607, 609, 615
Manufacturing costs. *See also* Cost and revenue functions/ breakeven points
 bicycles, 233
 calculator, 458
 PDAs, 590
 portable satellite radio players, 461
 tents, 615
 virtual reality headsets, 411, 424–425
 wheelchair, 425
Marching band, 560
Marijuana use by U.S. high school seniors, 104
- Marital status
 unmarried Americans (ages 25–29), 268, 270
 of U.S. population, 557, 819–820, 822
Markup, 137
Marriage, interracial, percentage of Americans in favor of laws prohibiting, 212
Marriage age
 of men, 339
 preferred age in a mate, 322–323
 of wife, probability of divorce and, 100–101
Marriage equality, U.S. public opinion on, 531, 558
Mathematics department
 personnel, random selection from, 824
Mathematics exam problems, 809
Maximum area, 358, 361, 410, 457
Maximum height, 832
Maximum product, 361, 410, 460, 765
Maximum profit, 410, 460, 607, 616
Maximum scores, 610
Maximum yield, 363
Median age. *See under* Age(s)
Mega Millions, probability of winning, 823
Memory retention, 476, 491, 492, 516, 536
Mental illness, number of U.S. adults with, 538
Miles per gallon, 235
Military, gay service members discharged from, 279–280
Minimum product, 357, 457
Miscarriages, by age, 531
Mixture problems, 122, 233, 552–554, 559, 590, 613, 616, 643
Modernistic painting consisting of geometric figures, 569
Moiré patterns, 721
Moon weight of person given Earth weight, 452
Moth eggs and abdominal width, 382, 393
Movies
 ranking, 808
 ticket price of, 210
 top ten Oscar-winning, 313
Multiple-choice test, 800–801, 807, 831
Multiplier effect, 776–777
- N**
National debt, 20, 31–32, 34, 35, 91
National diversity index, 90
National Football League (NFL) broadcasts, time devoted to game action, 817
Natural disaster relief, 610
Nature, Fibonacci numbers found in, 744
Negative life events, sense of humor and response to, 106–107, 118–119
- Negative numbers, square roots of, 139
Negative square roots, 147
Neurons in human vs. gorilla brain, 63
Newton's Law of Cooling, 533
NFL (National Football League) broadcasts, time devoted to game action, 817
Nutritional content, 632, 642
- O**
Oculus Rift headset manufacturing costs, 411, 424–425
Officers for Internet marketing consulting firm, choosing, 802–803
Ohm's law, 147
One-person households. *See* Living alone, number of Americans
Online games, percentage of U.S. college students playing, 559
Open box lengths and widths, 170
Orbits
 of comets, 588, 702, 717, 721, 730
 perigee/apogee of satellite's orbit, 706
 of planets, 588, 701, 705
Oscar-winning films, top ten, 313
- P**
Palindromic numbers, 824
Panic attack, heart rate before and during, 380
Parabolic arch and boat clearance, 736
Paragraph formation, 808
Park, pedestrian route around, 169
Parking lot, dimensions of, 169
Parthenon at Athens, as golden rectangle, 50
Password construction, 807, 808
Path around swimming pool, dimensions of, 137
Pay phones in U.S., number of (2000–2006), 123
Payroll spent in town, 829
PC (personal computer) sales, 537
PDA manufacturing costs and revenues, 590
Pedestrian route around park, 169
Pen and pad, cost of, 832
Pen choices, 807
Pendulum swings, 779
Per capita income and national happiness, 269
Perceived length of time period and age, 453
Perigee/apogee of satellite's orbit, 706
Personal computer (PC) sales, 537
Pest-eradication program, 780
Pets
 insurance for, 253
 spending on, 755–756
- pH
 of human mouth after eating sugar, 428
 scale, 516–517
Phone calls between cities, 444, 453
Photography. *See* Digital photography
Physician visits, 254
Piano keyboard, Fibonacci numbers on, 744
Pitch of a musical tone, 459
Pizza, size and topping options, 800
Planets
 elliptical orbits, 701
 years, 187
Playground, dimensions of, 361
Playing cards. *See* Deck of 52 cards, probability and
Poker hands, 806
Police officers, average salary, 32
Political affiliation, academic major and, 824
Political identification
 college freshmen, 339
 Implicit Association Test scores, 62
Pollutants in the air, 687
Pollution removal costs, 76
Pool dimensions, 137, 169
Population
 Africa, 521
 alligator, 172
 Asia, 539
 bird species in danger of extinction, 530
 Bulgaria, 529
 California, 515, 778
 Canada, 533
 Colombia, 529
 elk, 540
 Europe, 590
 exponential growth modeling, 529, 530
 Florida, 603, 828–829
 foreign-born (U.S.), 172, 569
 geometric growth in, 768–769
 Germany, 529, 539
 gray wolf, 470–471
 Hispanic, 538
 Hungary, 518
 India, 475, 529
 Iraq, 529
 Israel, 529
 Japan, 529
 Madagascar, 529
 Mexico, 530
 New Zealand, 530
 Nigeria, 532
 over age 65 (U.S.), 532
 Pakistan, 529
 Palestinian, 529
 Philippines, 529
 racial and ethnic breakdown of, 632–633
 Russia, 529
 in scientific notation, 30
 single, 271–272, 274–275
 Texas, 515, 779

- tigers, worldwide, 379
 Uganda, 533
 United States
 age 65 and older, 532
 by gender, 311, 459
 modeling growth of, 520–521
 percentage never married,
 ages 25–29, 268, 270
 by race/ethnicity, 759–760
 total tax collections and, 34
 and walking speed, 525
 world, 92, 312, 519, 526–528, 531,
 539
 Population projections, 49–50, 136,
 529
 Potassium-40, 530
 Powerball, probability of winning,
 815–816, 824
 Price(s)
 advertising and, 449–450, 454
 computer, 314, 533
 gasoline, 380, 556–557
 of a house, 234, 781
 jeans, 312
 of movie ticket, 210
 of rock concert ticket, 828
 supply/demand and, 556–557
 Price reductions, 129–130, 137, 138,
 172, 210, 214, 314
 Pricing options, 206
 Prison population
 mandatory minimum sentences
 and, 558
 violent crime and, 589
 Problem solving, payments for, 138
 Problem solving time, 450
 Profit function, 362, 552, 556, 590,
 604
 Profits
 department store branches, 312
 maximizing, 362, 410, 460, 609,
 610, 615, 616
 maximum, 460
 maximum daily, 607, 633
 maximum monthly, 609
 on newsprint/writing paper,
 615
 production and sales for gains
 in, 205
 total monthly, 609
 Projectiles, paths of, 346, 459.
See also Ball's height above
 ground; Free-falling object's
 position
 Pyramid volume, 459
- R**
 Racial diversity, 90
 Racial prejudice, Implicit
 Association Test for, 51,
 61–62
 Radiation intensity and distance of
 radiation machine, 452
 Radio manufacturing/sales, 556
 Radio show programming, 808
 Radio station call letters, 807
 Radio towers on coast, distance of
 ship from, 720, 739
- Raffle prizes, 807, 808
 Rain gutter cross-sectional area,
 170, 361
 Rate of travel
 airplane rate, 559
 average rate and time traveled,
 233
 average rate on a round-trip
 commute, 88
 rowing rate, 559
 and time for trip, 447
 Razor blades sold, 568
 Real-estate sales and prices (U.S.),
 781
 Rectangle
 area of, 50
 dimensions of, 169, 172, 212, 297,
 442, 560, 585–586, 588, 614,
 616, 617, 685, 780
 dimensions of, maximizing
 enclosed area, 358
 golden, 50
 perimeter of, 50, 88, 123
 Rectangular box dimensions, 393
 Rectangular carpet dimensions,
 214
 Rectangular field dimensions, 211
 Rectangular garden
 dimensions of, 343
 width of path around, 170
 Rectangular sign dimensions,
 170
 Rectangular solid, volume of, 62
 Reflecting telescopes, 731
 Reflections, 287
 Relativity theory, space
 exploration and, 35, 47, 50
 Religious affiliation
 first-year U.S. college students
 claiming no, 217–218, 220
 spouses with different, 204
 Rental
 car, 189–190, 200–201, 212, 430
 rug cleaner, 136
 truck, 205, 742
 Repair bill
 cost of parts and labor on, 137
 estimate, 205
 Residential community costs,
 adult, 755, 762
 Resistance, electrical, 147, 453, 832
 Restaurant tables and maximum
 occupancy, 559
 Revenue functions. *See* Cost
 and revenue functions/
 break-even points
 Reversibility of thought, 64
 Right triangle, isosceles, 170
 Roads to expressway, length of, 188
 Rock concerts, ticket price
 increase, 828
 Roulette wheel, independent events
 on, 821
 Royal flush (poker hand),
 probability of, 806
 Rug cleaner rental rates, 136
 Rug's length and width, 588
 Runner's pulse, 517
- S**
 Salary(-ies)
 after college, 209
 choosing between pay
 arrangements, 343
 college education and, 135–136
 college graduates with
 undergraduate degrees,
 125–126
 comparing, 764–766
 earnings with overtime, 540
 gross amount per paycheck, 137
 lifetime computation, 771–772,
 779
 over six-year period, 829
 over ten-year period, 828
 police officers, average, 32
 salesperson's earnings/
 commissions, 210, 832
 summer sales job, 343
 total, 765, 779, 829, 830
 wage gap in, by gender, 233
 weekly, 123, 609
 Sale prices, 75. *See also* Price
 reductions
 Sales figures
 PC vs. tablet, 537
 price/advertising and, 449–450,
 454
 real estate, 781
 theater ticket, 568
 Salesperson's earnings, 210, 832
 Satellite, apogee/perigee of orbit,
 706
 Satellite dish, 731, 736, 740
 Satellite radio players,
 manufacturing costs of, 461
 Savings
 and compound interest, 515–516
 geometric sequencing, 778, 779
 needed for health-care expenses
 during retirement, 531
 total, 779
 Scattering experiments, 720
 Scheduling of appearances, 808
 Semi-elliptical archway and truck
 clearance, 702–703, 705,
 722, 739
 Sense of humor, depression and,
 106–107
 Shaded region areas, 62, 75
 Shading process, 780
 Shadows, hyperbolic, 707
 Shipping cost, 339. *See also*
 Mailing costs
 Ship tracking system, 588
 Shot put
 angle and height of, 360–361
 path of, given angle, 169
 Shower, gallons of water used
 during, 722
 Skeletons, carbon-14 dating of, 530
 Skydiver's fall, 446–447, 459
 Sleep
 average number of awakenings
 during night, by age and
 gender, 104
 coffee consumption and, 540
 college students' nightly hours
 of, 559
 death rate and hours of, 561, 565
 hours of, on typical night, 810
 Smoking
 among Americans, by ethnicity,
 613
 deaths and disease incidence
 ratios, 429
 and heart disease, 430
 incidence of ailments, smokers
 vs. non-smokers, 796–797
 Soccer field dimension, 137
 Social Security benefits/costs, 213
 Soda (soft drinks), U.S. per capita
 consumption, 558
 Solar energy industry, number of
 U.S. jobs in, 538
 Sonic boom, hyperbolic shape of,
 717
 Sound intensity, 257, 453, 459, 491,
 502, 531, 539
 Space exploration and relativity
 theory, 35, 47, 50
 Space flight/travel
 aging rate and, 35, 47, 50
 Freedom 7 spacecraft, 324
 Hubble Space Telescope, 454,
 723, 731, 732
 relativity theory and, 35, 47, 50
 Spaceguard Survey, 721
 Speaker loudness, 459
 Speed. *See* Rate of travel
 Spinner, probability of pointer
 landing in specific way, 819,
 823, 830, 831
 Spouses with different faiths, 204
 Spring, force required to stretch, 452
 Square, length of side of, 170
 Stadium seats, 765
 Standbys for airline seats, 808
 Stereo speaker loudness, 459
 Stolen plants, 138
 Stomach acid, pH of, 517
 Stopping distances
 for car, 431, 441–442
 for motorcycles at selected
 speeds, 459
 for trucks, 442
 Stories, matching graphs with, 105
 Stress levels, 359
 String length and frequency, 449
 Strontium-90, 523
 Student government elections, 804
 Student loan debt, 63
 Students, probability of selecting
 specific, 831
 Studying, hours per week by
 college students, 567–568
 Sunscreen, exposure time without
 burning and, 2
 Supply and demand, 556–557
 Supply-side economics, 394
 Surface sunlight, intensity beneath
 ocean's surface, 515
 Sushi, population who won't try, 531
 Suspension bridges, parabolas
 formed by, 730, 736, 740

- Swimming pool
 path around, 137, 170
 tile border, 171
- Systolic blood pressure, age and,
 163–164
- T**
- Tablet sales, 537
- Talent contest, picking winner and
 runner-up in, 809
- Target, probability of hitting, 824
- Target heart rate for exercise, 18
- Task mastery, 502, 537
- Taxes
 bills, 205
 federal tax rate schedule for tax
 owed, 253
 government spending and, 34
 income
 corporate, 172
 federal, 234
 inn charges before, 137
 rebate and multiplier effect,
 776–777, 780
 tax rate percentage and revenue,
 394
 U.S. population and total tax
 collections, 34
- Teenage drug use, 531
- Telephone(s)
 number of pay phones in U.S.
 (2000–2006), 123
 replacement of land lines with
 cell phones, 557
- Telephone numbers in United
 States, 801, 831
- Telephone plans
 cellular plans, 210, 234, 643
 per-minute costs, 245–246, 252
 texting plans, 123, 135, 205, 214
- Television
 manufacturing profits and
 constraints, 609
 programming of movies, 808
 sale prices, 75
 screen area, 165
 screen dimensions, 164–165, 443,
 588
 viewing, by annual income, 184
- Temperature
 of cooling cup of coffee, 536
 degree-days, 765
 and depth of water, 452
 in enclosed vehicle, increase in,
 487–488
- Fahrenheit-Celsius
 interconversions, 17, 204
 global warming, 215, 264–266
 home temperature as function of
 time, 296–297
 increase in an enclosed vehicle,
 531
 Newton's Law of Cooling, 533
 time-temperature flu scenario,
 235–236
- Tennis club payment options, 138
- Tennis court dimensions, 137
- Test scores, maximum, 610
- Texting plans, 123, 135, 205, 214
- Theater attendance, maximizing
 revenue from, 610
- Theater seats, 765, 828
- Theater ticket sales, 568
- Thefts in U.S., 457
- Thorium-229, 530
- Ticket prices/sales
 movie ticket prices, 210
 rock concert prices, 828
 theater ticket sales, 568
- Tigers, worldwide population,
 379
- Time, perceived length of, 453
- Time traveled, average rate and,
 233
- Tolls, 128–129, 136, 172, 205, 312
- Traffic control, 634, 638–643, 688
- Transformations of an image,
 653–654, 656, 688
- Triangle
 area, 684
 isosceles, 170, 559
- Trucks
 clearance through semi-elliptical
 archway, 702–703, 705, 722,
 739
 rental costs, 205, 742
 stopping distances required for,
 442
- Tuition, government aid for, 211
- TV. *See* Television
- U**
- Unemployment and years of
 education, 459
- U.S. citizenship, number of
 Americans renouncing, 753
- Universe imagery, 723
- V**
- Vacation lodgings, 601
- Vacation plan packages, cost of,
 614
- Vaccine, mixture for flu, 233,
 552–554
- Value
 of an annuity, 779, 829
 of car, over time, 754
 of house, inflation rate and, 476
 of investments, 471–473, 475, 512
- Van, groups fitting into, 808
- Vehicle fatalities, driver's age and,
 169
- Vertical pole supported by wire,
 172, 214
- Video games, retail sales of, 518
- Violent crime
 decrease in, 270
 prison population and, 589
- Violin string length and frequency,
 449
- Virtual reality headset
 manufacturing costs, 411,
 424–425
- Vitamin content, 642
- Volume (sound). *See* Sound
 intensity
- Volume (space)
 of carry-on luggage, 407–408
 of cone, 451
 for given regions, 75
 of open box, 62
 of solid, 409
- Voters, age and gender of, 657
- Voting ballot, 808
- W**
- Wage gap, 233
- Wages. *See* Salary(-ies)
- Walking speed and city population,
 525
- Wardrobe selection, 798–800
- Water
 bottled, U.S. per capita
 consumption, 558
 gallons used during shower, 722
 pressure and depth, 444–445
 temperature and depth, 452
 used in a shower, 446
- Water pipe diameter, number of
 houses served and size of,
 452
- Water supply produced by
 snowpack, 459
- Weight
 blood volume and body, 445–446
 elephant's, age and, 517
 of great white shark, cube of its
 length and, 447
 healthy, for height and age, 541,
 595–596, 601–602
 and height recommendations/
 calculations, 137, 452
 of human fetus, age and, 211
 moon weight of person given
 Earth weight, 452
- Weightlifting, 532
- Wheelchair business
 manufacturing costs, 425
 profit function for, 552
 revenue and cost functions for,
 550–551
- Wheelchair ramp, vertical distance
 of, 169
- Whispering gallery, 701, 705, 706,
 741
- White House, rooms, bathrooms,
 fireplaces and elevators
 in, 633
- Will distribution, 138
- Wind force, 453
- Wind pressure, 453
- Wine consumption, heart disease
 and, 269–270
- Wire length, 170
- Women. *See also* Gender
 average level of happiness at
 different times of day, 323
 and housework, 491
 in the labor force, 187
 percentage of college graduates
 among Americans ages 25
 and older, 764
 workforce participation, 620
- Workforce, percentage of U.S.
 women in, 620
- X**
- Xanax, half-life of, 530

Prerequisites: Fundamental Concepts of Algebra

CHAPTER P

What can algebra possibly have to tell me about

- the skyrocketing cost of a college education?
- student-loan debt?
- my workouts?
- the effects of alcohol?
- the meaning of the national debt that is nearly \$19 trillion?
- time dilation on a futuristic high-speed journey to a nearby star?
- racial bias?
- ethnic diversity in the United States?
- the widening imbalance between numbers of women and men on college campuses?

This chapter reviews fundamental concepts of algebra that are prerequisites for the study of college algebra. Throughout the chapter, you will see how the special language of algebra describes your world.

HERE'S WHERE YOU'LL FIND THESE APPLICATIONS:

College costs: Section P.1, Example 2; Exercise Set P.1, Exercises 131–132

Student-loan debt: Mid-Chapter Check Point, Exercise 31

Workouts: Exercise Set P.1, Exercises 129–130

The effects of alcohol: Blitzer Bonus beginning on page 15

The national debt: Section P.2, Example 12

Time dilation: Blitzer Bonus on page 47

Racial bias: Exercise Set P.4, Exercises 91–92

U.S. ethnic diversity: Chapter P Review, Exercise 23

College gender imbalance: Chapter P Test, Exercise 32.

Section P.1

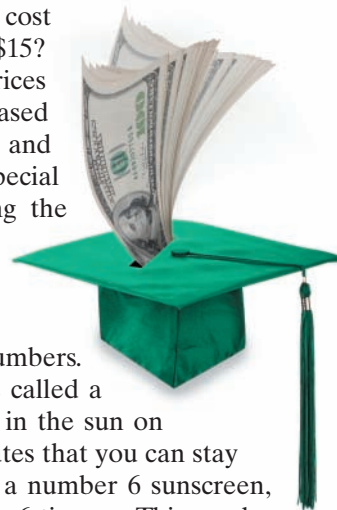
Algebraic Expressions, Mathematical Models, and Real Numbers

What am I supposed to learn?

After studying this section, you should be able to:

- 1 Evaluate algebraic expressions.
- 2 Use mathematical models.
- 3 Find the intersection of two sets.
- 4 Find the union of two sets.
- 5 Recognize subsets of the real numbers.
- 6 Use inequality symbols.
- 7 Evaluate absolute value.
- 8 Use absolute value to express distance.
- 9 Identify properties of the real numbers.
- 10 Simplify algebraic expressions.

How would your lifestyle change if a gallon of gas cost \$9.15? Or if the price of a staple such as milk was \$15? That's how much those products would cost if their prices had increased at the same rate college tuition has increased since 1980. (Source: Center for College Affordability and Productivity) In this section, you will learn how the special language of algebra describes your world, including the skyrocketing cost of a college education.



Algebraic Expressions

Algebra uses letters, such as x and y , to represent numbers. If a letter is used to represent various numbers, it is called a **variable**. For example, imagine that you are basking in the sun on the beach. We can let x represent the number of minutes that you can stay in the sun without burning with no sunscreen. With a number 6 sunscreen, exposure time without burning is six times as long, or 6 times x . This can be written $6 \cdot x$, but it is usually expressed as $6x$. Placing a number and a letter next to one another indicates multiplication.

Notice that $6x$ combines the number 6 and the variable x using the operation of multiplication. A combination of variables and numbers using the operations of addition, subtraction, multiplication, or division, as well as powers or roots, is called an **algebraic expression**. Here are some examples of algebraic expressions:

$$x + 6, \quad x - 6, \quad 6x, \quad \frac{x}{6}, \quad 3x + 5, \quad x^2 - 3, \quad \sqrt{x} + 7.$$

Many algebraic expressions involve *exponents*. For example, the algebraic expression

$$4x^2 + 330x + 3310$$

approximates the average cost of tuition and fees at public U.S. colleges for the school year ending x years after 2000. The expression x^2 means $x \cdot x$ and is read “ x to the second power” or “ x squared.” The exponent, 2, indicates that the base, x , appears as a factor two times.

Exponential Notation

If n is a counting number (1, 2, 3, and so on),

$$b^n = \underbrace{b \cdot b \cdot b \cdot \cdots \cdot b}_n$$

b appears as a factor n times.

b^n is read “the n th power of b ” or “ b to the n th power.” Thus, the n th power of b is defined as the product of n factors of b . The expression b^n is called an **exponential expression**. Furthermore, $b^1 = b$.

For example,

$$8^2 = 8 \cdot 8 = 64, \quad 5^3 = 5 \cdot 5 \cdot 5 = 125, \quad \text{and} \quad 2^4 = 2 \cdot 2 \cdot 2 \cdot 2 = 16.$$

1 Evaluate algebraic expressions.

Evaluating Algebraic Expressions

Evaluating an algebraic expression means to find the value of the expression for a given value of the variable.

Many algebraic expressions involve more than one operation. Evaluating an algebraic expression without a calculator involves carefully applying the following order of operations agreement:

The Order of Operations Agreement


1. Perform operations within the innermost parentheses and work outward. If the algebraic expression involves a fraction, treat the numerator and the denominator as if they were each enclosed in parentheses.
2. Evaluate all exponential expressions.
3. Perform multiplications and divisions **as they occur**, working **from left to right**.
4. Perform additions and subtractions **as they occur**, working **from left to right**.

EXAMPLE 1 Evaluating an Algebraic Expression

Evaluate $7 + 5(x - 4)^3$ for $x = 6$.

SOLUTION

$$\begin{aligned}
 7 + 5(x - 4)^3 &= 7 + 5(6 - 4)^3 && \text{Replace } x \text{ with } 6. \\
 &= 7 + 5(2)^3 && \text{First work inside parentheses: } 6 - 4 = 2. \\
 &= 7 + 5(8) && \text{Evaluate the exponential expression: } 2^3 = 2 \cdot 2 \cdot 2 = 8. \\
 &= 7 + 40 && \text{Multiply: } 5(8) = 40. \\
 &= 47 && \text{Add.}
 \end{aligned}$$

 **Check Point 1** Evaluate $8 + 6(x - 3)^2$ for $x = 13$.

2 Use mathematical models.

Formulas and Mathematical Models

An **equation** is formed when an equal sign is placed between two algebraic expressions. One aim of algebra is to provide a compact, symbolic description of the world. These descriptions involve the use of *formulas*. A **formula** is an equation that uses variables to express a relationship between two or more quantities.

Here are two examples of formulas related to heart rate and exercise.



Couch-Potato Exercise

$$H = \frac{1}{5}(220 - a)$$

Heart rate, in beats per minute, is $\frac{1}{5}$ of the difference between 220 and your age.



Working It

$$H = \frac{9}{10}(220 - a)$$

Heart rate, in beats per minute, is $\frac{9}{10}$ of the difference between 220 and your age.

The process of finding formulas to describe real-world phenomena is called **mathematical modeling**. Such formulas, together with the meaning assigned to the variables, are called **mathematical models**. We often say that these formulas model, or describe, the relationships among the variables.

EXAMPLE 2 Modeling the Cost of Attending a Public College

The bar graph in **Figure P.1** shows the average cost of tuition and fees for public four-year colleges, adjusted for inflation. The formula

$$T = 4x^2 + 330x + 3310$$

models the average cost of tuition and fees, T , for public U.S. colleges for the school year ending x years after 2000.

- Use the formula to find the average cost of tuition and fees at public U.S. colleges for the school year ending in 2010.
- By how much does the formula underestimate or overestimate the actual cost shown in **Figure P.1**?

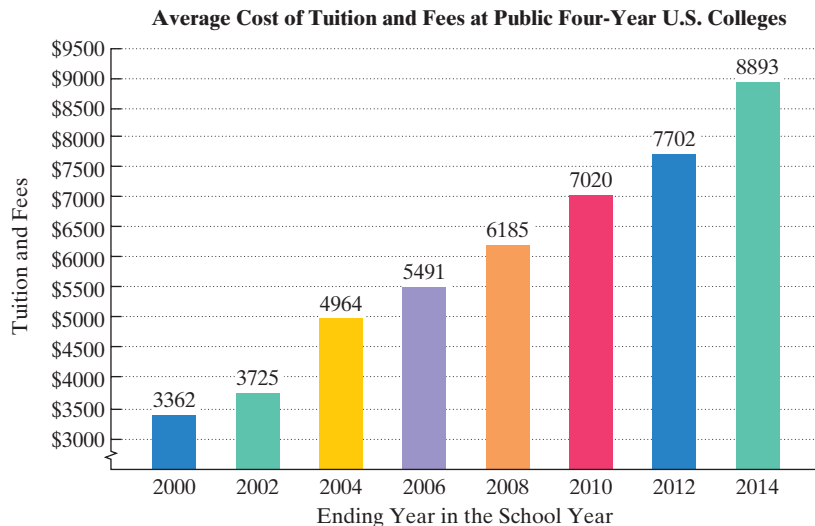


FIGURE P.1
Source: The College Board

SOLUTION

- Because 2010 is 10 years after 2000, we substitute **10** for x in the given formula. Then we use the order of operations to find T , the average cost of tuition and fees for the school year ending in 2010.

$$T = 4x^2 + 330x + 3310 \quad \text{This is the given mathematical model.}$$

$$T = 4(10)^2 + 330(10) + 3310 \quad \text{Replace each occurrence of } x \text{ with } 10.$$

$$T = 4(100) + 330(10) + 3310 \quad \text{Evaluate the exponential expression: } 10^2 = 10 \cdot 10 = 100.$$

$$T = 400 + 3300 + 3310 \quad \text{Multiply from left to right: } 4(100) = 400 \text{ and } 330(10) = 3300.$$

$$T = 7010 \quad \text{Add.}$$

The formula indicates that for the school year ending in 2010, the average cost of tuition and fees at public U.S. colleges was \$7010.

- Figure P.1** shows that the average cost of tuition and fees for the school year ending in 2010 was \$7020.

The cost obtained from the formula, \$7010, underestimates the actual data value by $\$7020 - \7010 , or by \$10. ●●●

Blitzer Bonus || Is College Worthwhile?

“Questions have intensified about whether going to college is worthwhile,” says *Education Pays*, released by the College Board Advocacy & Policy Center. “For the typical student, the investment pays off very well over the course of a lifetime, even considering the expense.”

Among the findings in *Education Pays*:

- Mean (average) full-time earnings with a bachelor’s degree in 2014 were \$62,504, which is \$27,768 more than high school graduates.
- Compared with a high school graduate, a four-year college graduate who enrolled in a public university at age 18 will break even by age 33. The college graduate will have earned enough by then to compensate for being out of the labor force for four years and for borrowing enough to pay tuition and fees, shown in **Figure P.1**.

Check Point 2

- Use the formula $T = 4x^2 + 330x + 3310$, described in Example 2, to find the average cost of tuition and fees at public U.S. colleges for the school year ending in 2014.
- By how much does the formula underestimate or overestimate the actual cost shown in **Figure P.1**?

Sometimes a mathematical model gives an estimate that is not a good approximation or is extended to include values of the variable that do not make sense. In these cases, we say that **model breakdown** has occurred. For example, it is not likely that the formula in Example 2 would give a good estimate of tuition and fees in 2050 because it is too far in the future. Thus, model breakdown would occur.

Sets

Before we describe the set of real numbers, let’s be sure you are familiar with some basic ideas about sets. A **set** is a collection of objects whose contents can be clearly determined. The objects in a set are called the **elements** of the set. For example, the set of numbers used for counting can be represented by

$$\{1, 2, 3, 4, 5, \dots\}.$$

The braces, $\{ \}$, indicate that we are representing a set. This form of representation, called the **roster method**, uses commas to separate the elements of the set. The symbol consisting of three dots after the 5, called an *ellipsis*, indicates that there is no final element and that the listing goes on forever.

A set can also be written in **set-builder notation**. In this notation, the elements of the set are described but not listed. Here is an example:

$$\{x \mid x \text{ is a counting number less than } 6\}.$$

The set of all x such that x is a counting number less than 6.

The same set written using the roster method is

$$\{1, 2, 3, 4, 5\}.$$

If A and B are sets, we can form a new set consisting of all elements that are in both A and B . This set is called the *intersection* of the two sets.

Definition of the Intersection of Sets

The **intersection** of sets A and B , written $A \cap B$, is the set of elements common to both set A and set B . This definition can be expressed in set-builder notation as follows:

$$A \cap B = \{x \mid x \text{ is an element of } A \text{ AND } x \text{ is an element of } B\}.$$

GREAT QUESTION!

Can I use symbols other than braces when writing sets using the roster method?

No. Grouping symbols such as parentheses, $()$, and square brackets, $[]$, are not used to represent sets in the roster method. Furthermore, only commas are used to separate the elements of a set. Separators such as colons or semicolons are not used.

- Find the intersection of two sets.

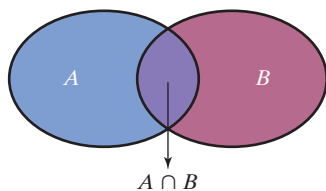


FIGURE P.2 Picturing the intersection of two sets

Figure P.2 shows a useful way of picturing the intersection of sets A and B . The figure indicates that $A \cap B$ contains those elements that belong to both A and B at the same time.

EXAMPLE 3 Finding the Intersection of Two Sets

Find the intersection: $\{7, 8, 9, 10, 11\} \cap \{6, 8, 10, 12\}$.

SOLUTION

The elements common to $\{7, 8, 9, 10, 11\}$ and $\{6, 8, 10, 12\}$ are 8 and 10 . Thus,

$$\{7, 8, 9, 10, 11\} \cap \{6, 8, 10, 12\} = \{8, 10\}. \quad \dots$$

Check Point 3 Find the intersection: $\{3, 4, 5, 6, 7\} \cap \{3, 7, 8, 9\}$.

If a set has no elements, it is called the **empty set**, or the **null set**, and is represented by the symbol \emptyset (the Greek letter phi). Here is an example that shows how the empty set can result when finding the intersection of two sets:

$$\{2, 4, 6\} \cap \{3, 5, 7\} = \emptyset.$$

These sets have no common elements.

Their intersection has no elements and is the empty set.

4 Find the union of two sets.

Another set that we can form from sets A and B consists of elements that are in A or B or in both sets. This set is called the *union* of the two sets.

Definition of the Union of Sets

The **union** of sets A and B , written $A \cup B$, is the set of elements that are members of set A **or** of set B or of both sets. This definition can be expressed in set-builder notation as follows:

$$A \cup B = \{x \mid x \text{ is an element of } A \text{ OR } x \text{ is an element of } B\}.$$

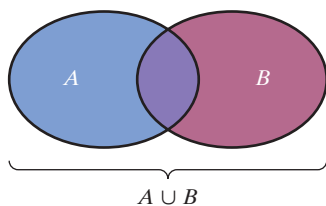


FIGURE P.3 Picturing the union of two sets

Figure P.3 shows a useful way of picturing the union of sets A and B . The figure indicates that $A \cup B$ is formed by joining the sets together.

We can find the union of set A and set B by listing the elements of set A . Then we include any elements of set B that have not already been listed. Enclose all elements that are listed with braces. This shows that the union of two sets is also a set.

EXAMPLE 4 Finding the Union of Two Sets

Find the union: $\{7, 8, 9, 10, 11\} \cup \{6, 8, 10, 12\}$.

SOLUTION

To find $\{7, 8, 9, 10, 11\} \cup \{6, 8, 10, 12\}$, start by listing all the elements from the first set, namely, $7, 8, 9, 10$, and 11 . Now list all the elements from the second set that are not in the first set, namely, 6 and 12 . The union is the set consisting of all these elements. Thus,

$$\{7, 8, 9, 10, 11\} \cup \{6, 8, 10, 12\} = \{6, 7, 8, 9, 10, 11, 12\}.$$

Although 8 and 10 appear in both sets,

do not list 8 and 10 twice. ...

Check Point 4 Find the union: $\{3, 4, 5, 6, 7\} \cup \{3, 7, 8, 9\}$.

GREAT QUESTION!

How can I use the words *union* and *intersection* to help me distinguish between these two operations?

Union, as in a marriage union, suggests joining things, or uniting them. Intersection, as in the intersection of two crossing streets, brings to mind the area common to both, suggesting things that overlap.

5 Recognize subsets of the real numbers.

The Set of Real Numbers

The sets that make up the real numbers are summarized in **Table P.1**. We refer to these sets as **subsets** of the real numbers, meaning that all elements in each subset are also elements in the set of real numbers.

Table P.1 Important Subsets of the Real Numbers

Name/Symbol	Description	Examples
Natural numbers \mathbb{N}	$\{1, 2, 3, 4, 5, \dots\}$ These are the numbers that we use for counting.	2, 3, 5, 17
Whole numbers \mathbb{W}	$\{0, 1, 2, 3, 4, 5, \dots\}$ The set of whole numbers includes 0 and the natural numbers.	0, 2, 3, 5, 17
Integers \mathbb{Z}	$\{\dots, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, \dots\}$ The set of integers includes the negatives of the natural numbers and the whole numbers.	-17, -5, -3, -2, 0, 2, 3, 5, 17
Rational numbers \mathbb{Q}	$\left\{\frac{a}{b} \mid a \text{ and } b \text{ are integers and } b \neq 0\right\}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">This means that b is not equal to zero.</div> The set of rational numbers is the set of all numbers that can be expressed as a quotient of two integers, with the denominator not 0. Rational numbers can be expressed as terminating or repeating decimals.	$-17 = \frac{-17}{1}$, $-5 = \frac{-5}{1}$, -3, -2, 0, 2, 3, 5, 17, $\frac{2}{5} = 0.4$, $\frac{-2}{3} = -0.6666\dots = -0.\bar{6}$
Irrational numbers \mathbb{I}	The set of irrational numbers is the set of all numbers whose decimal representations are neither terminating nor repeating. Irrational numbers cannot be expressed as a quotient of integers.	$\sqrt{2} \approx 1.414214$ $-\sqrt{3} \approx -1.73205$ $\pi \approx 3.142$ $-\frac{\pi}{2} \approx -1.571$

Notice the use of the symbol \approx in the examples of irrational numbers. The symbol means “is approximately equal to.” Thus,

$$\sqrt{2} \approx 1.414214.$$

TECHNOLOGY

A calculator with a square root key gives a decimal approximation for $\sqrt{2}$, not the exact value.

We can verify that this is only an approximation by multiplying 1.414214 by itself. The product is very close to, but not exactly, 2:

$$1.414214 \times 1.414214 = 2.000001237796.$$

Not all square roots are irrational. For example, $\sqrt{25} = 5$ because $5^2 = 5 \cdot 5 = 25$. Thus, $\sqrt{25}$ is a natural number, a whole number, an integer, and a rational number ($\sqrt{25} = \frac{5}{1}$).

The set of *real numbers* is formed by taking the union of the sets of rational numbers and irrational numbers. Thus, every real number is either rational or irrational, as shown in **Figure P.4**.

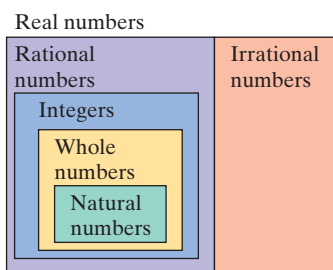


FIGURE P.4 Every real number is either rational or irrational.

Real Numbers

The set of **real numbers** is the set of numbers that are either rational or irrational:

$$\{x \mid x \text{ is rational or } x \text{ is irrational}\}.$$

The symbol \mathbb{R} is used to represent the set of real numbers. Thus,

$$\mathbb{R} = \{x \mid x \text{ is rational}\} \cup \{x \mid x \text{ is irrational}\}.$$

EXAMPLE 5 Recognizing Subsets of the Real Numbers

Consider the following set of numbers:

$$\left\{-7, -\frac{3}{4}, 0, 0.\overline{6}, \sqrt{5}, \pi, 7.3, \sqrt{81}\right\}.$$

List the numbers in the set that are

- a.** natural numbers. **b.** whole numbers. **c.** integers.
d. rational numbers. **e.** irrational numbers. **f.** real numbers.

SOLUTION

- a.** Natural numbers: The natural numbers are the numbers used for counting. The only natural number in the set $\{-7, -\frac{3}{4}, 0, 0.\overline{6}, \sqrt{5}, \pi, 7.3, \sqrt{81}\}$ is $\sqrt{81}$ because $\sqrt{81} = 9$. (9 multiplied by itself, or 9^2 , is 81.)
- b.** Whole numbers: The whole numbers consist of the natural numbers and 0. The elements of the set $\{-7, -\frac{3}{4}, 0, 0.\overline{6}, \sqrt{5}, \pi, 7.3, \sqrt{81}\}$ that are whole numbers are 0 and $\sqrt{81}$.
- c.** Integers: The integers consist of the natural numbers, 0, and the negatives of the natural numbers. The elements of the set $\{-7, -\frac{3}{4}, 0, 0.\overline{6}, \sqrt{5}, \pi, 7.3, \sqrt{81}\}$ that are integers are $\sqrt{81}$, 0, and -7 .
- d.** Rational numbers: All numbers in the set $\{-7, -\frac{3}{4}, 0, 0.\overline{6}, \sqrt{5}, \pi, 7.3, \sqrt{81}\}$ that can be expressed as the quotient of integers are rational numbers. These include -7 ($-7 = \frac{-7}{1}$), $-\frac{3}{4}$ ($-\frac{3}{4} = \frac{-3}{4}$), 0 ($0 = \frac{0}{1}$), and $\sqrt{81}$ ($\sqrt{81} = \frac{9}{1}$). Furthermore, all numbers in the set that are terminating or repeating decimals are also rational numbers. These include $0.\overline{6}$ and 7.3.
- e.** Irrational numbers: The irrational numbers in the set $\{-7, -\frac{3}{4}, 0, 0.\overline{6}, \sqrt{5}, \pi, 7.3, \sqrt{81}\}$ are $\sqrt{5}$ ($\sqrt{5} \approx 2.236$) and π ($\pi \approx 3.14$). Both $\sqrt{5}$ and π are only approximately equal to 2.236 and 3.14, respectively. In decimal form, $\sqrt{5}$ and π neither terminate nor have blocks of repeating digits.
- f.** Real numbers: All the numbers in the given set $\{-7, -\frac{3}{4}, 0, 0.\overline{6}, \sqrt{5}, \pi, 7.3, \sqrt{81}\}$ are real numbers. ●●●



 **Check Point 5** Consider the following set of numbers:

$$\left\{-9, -1.3, 0, 0.\overline{3}, \frac{\pi}{2}, \sqrt{9}, \sqrt{10}\right\}.$$

List the numbers in the set that are

- a.** natural numbers **b.** whole numbers **c.** integers.
d. rational numbers **e.** irrational numbers **f.** real numbers.

The Real Number Line

The **real number line** is a graph used to represent the set of real numbers. An arbitrary point, called the **origin**, is labeled 0. Select a point to the right of 0 and label it 1. The distance from 0 to 1 is called the **unit distance**. Numbers to the right of the origin are **positive** and numbers to the left of the origin are **negative**. The real number line is shown in **Figure P.5**.

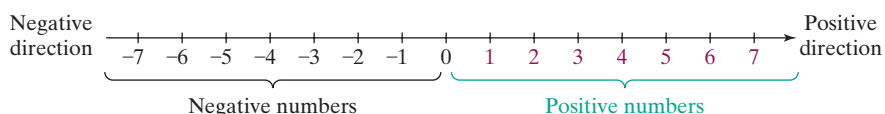
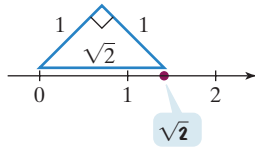


FIGURE P.5 The real number line

GREAT QUESTION!

How did you locate $\sqrt{2}$ as a precise point on the number line in Figure P.6?

We used a right triangle with two legs of length 1. The remaining side has a length measuring $\sqrt{2}$.



We'll have lots more to say about right triangles later in the book.

Real numbers are **graphed** on a number line by placing a dot at the correct location for each number. The integers are easiest to locate. In **Figure P.6**, we've graphed six rational numbers and three irrational numbers on a real number line.

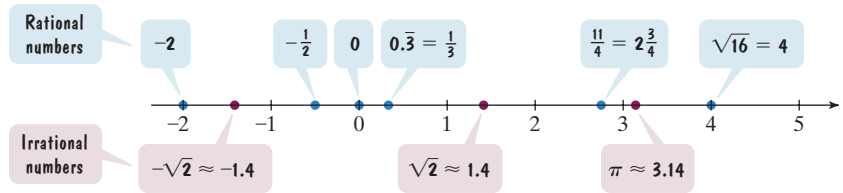


FIGURE P.6 Graphing numbers on a real number line

Every real number corresponds to a point on the number line and every point on the number line corresponds to a real number. We say that there is a **one-to-one correspondence** between all the real numbers and all points on a real number line.

6 Use inequality symbols.

Ordering the Real Numbers

On the real number line, the real numbers increase from left to right. The lesser of two real numbers is the one farther to the left on a number line. The greater of two real numbers is the one farther to the right on a number line.

Look at the number line in **Figure P.7**. The integers -4 and -1 are graphed.

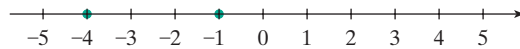


FIGURE P.7

Observe that -4 is to the left of -1 on the number line. This means that -4 is less than -1 .

$-4 < -1$ -4 is less than -1 because -4 is to the left of -1 on the number line.

In **Figure P.7**, we can also observe that -1 is to the right of -4 on the number line. This means that -1 is greater than -4 .

$-1 > -4$ -1 is greater than -4 because -1 is to the right of -4 on the number line.

The symbols $<$ and $>$ are called **inequality symbols**. These symbols always point to the lesser of the two real numbers when the inequality statement is true.

$-4 < -1$ -4 is less than -1. The symbol points to -4 , the lesser number.

$-1 > -4$ -1 is greater than -4. The symbol still points to -4 , the lesser number.

The symbols $<$ and $>$ may be combined with an equal sign, as shown in the following table:

	Symbols	Meaning	Examples	Explanation
<div style="border: 1px solid black; border-radius: 10px; padding: 5px; width: fit-content;"> This inequality is true if either the $<$ part or the $=$ part is true. </div>	$a \leq b$	a is less than or equal to b .	$2 \leq 9$ $9 \leq 9$	Because $2 < 9$ Because $9 = 9$
	$b \geq a$	b is greater than or equal to a .	$9 \geq 2$ $2 \geq 2$	Because $9 > 2$ Because $2 = 2$