

Donna Gerken

12 July

# Colege Agebro Second Edition







# Julie Miller Daytona State College

Digital contributions from

Donna Gerken Miami-Dade College Kendall





### COLLEGE ALGEBRA, SECOND EDITION

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### About the Authors

Julie Miller is from Daytona State College where she has taught developmental and upper-level mathematics courses for 20 years. Prior to her work at DSC, she worked as a software engineer for General Electric in the area of flight and radar simulation. Julie earned a bachelor of science in applied mathematics from Union College in Schenectady, New York, and a master of science in mathematics from the University of Florida. In addition to this textbook, she has authored textbooks in developmental mathematics, trigonometry, and precalculus, as well as several short works of fiction and nonfiction for young readers.

> "My father is a medical researcher, and I got hooked on math and science when I was young and would visit his laboratory. I remember doing simple calculations with him and using graph paper to plot data points for his experiments. He would then tell me what the peaks and features in the graph meant in the context of his experiment. I think that applications and hands-on experience made math come alive for me, and I'd like to see math come alive for my students."

**Donna Gerken** is a professor at Miami Dade College where she has taught developmental courses, honors classes, and upper-level mathematics classes for decades. Throughout her career she has been actively involved with many projects at Miami Dade including those on computer learning, curriculum design, and the use of technology in the classroom. Donna's bachelor of science in mathematics and master of science in mathematics are both from the University of Miami.

### Letter from the Authors

For many students, college algebra serves as a gateway course to the higher levels of mathematics needed for a variety of careers. Our goal is to offer every student an opportunity for success in college algebra by bringing together a seamless integration of print and digital content delivery. The clear, concise writing style and pedagogical features of our textbook continue throughout the online content in ConnectMath, in our instructional videos, and in the adaptive reading and learning experience of SmartBook.

The main objectives of this college algebra textbook and our digital content are threefold:

- · To provide students with a clear and logical presentation of fundamental concepts that will prepare them for continued study in mathematics.
- To help students develop logical thinking and problem-solving skills that will benefit them in all aspects of life.
- To motivate students by demonstrating the significance of mathematics in their lives through practical applications.

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### **Dedications**

 ${\it To}$  my parents Kent and Joanne Miller who have always taught me the value of education. -Julie Miller

For all the students who keep apologizing for asking too many questions. Keep doing that, and I'll keep listening. —Donna Gerken

# Table of Contents

Test 78

What Bridden

Index of Applications xvii

CHAPTER R

### Review of Prerequisites 1



Section R.1 Sets and the Real Number Line 2
Section R.2 Integer Exponents and Scientific Notation 18
Section R.3 Rational Exponents and Radicals 27
Section R.4 Polynomials and Multiplication of Radicals 38
Problem Recognition Exercises: Simplifying Algebraic Expressions 47
Section R.5 Factoring 47
Section R.6 Rational Expressions and More Operations on Radicals 59
Algebra for Calculus 72

Key Concepts 73
Review Exercises 75

CHAPTER 1



### Equations and Inequalities 81

- Section 1.1 Linear Equations and Rational Equations 82
- Section 1.2 Applications with Linear and Rational Equations 94
- Section 1.3 Complex Numbers 104
- Section 1.4 Quadratic Equations 113
- Problem Recognition Exercises: Simplifying Expressions Versus Solving Equations 125
- Section 1.5 Applications of Quadratic Equations 126
- Section 1.6 More Equations and Applications 133
- Section 1.7 Linear, Compound, and Absolute Value Inequalities 144
- Problem Recognition Exercises: Recognizing and Solving Equations and Inequalities 156

Equations and Inequalities for Calculus 157

Key Concepts 158 Review Exercises 160 Test 163 Cumulative Review Exercises 164

CHAPTER 2

### Functions and Relations 165



Section 2.1 The Rectangular Coordinate System and Graphing Utilities 166
Section 2.2 Circles 177
Section 2.3 Functions and Relations 183
Section 2.4 Linear Equations in Two Variables and Linear Functions 197
Section 2.5 Applications of Linear Equations and Modeling 213
Problem Recognition Exercises: Comparing Graphs of Equations 228
Section 2.6 Transformations of Graphs 229



285

491

 Section 2.7 Analyzing Graphs of Functions and Piecewise-Defined Functions 243
 Section 2.8 Algebra of Functions and Function Composition 262 Key Concepts 275 Review Exercises 277 Test 282 Cumulative Review Exercises 283

**Polynomial and Rational Functions** 

### CHAPTER 3



Section 3.1 Quadratic Functions and Applications 286
Section 3.2 Introduction to Polynomial Functions 300
Section 3.3 Division of Polynomials and the Remainder and Factor Theorems 316
Section 3.4 Zeros of Polynomials 329
Section 3.5 Rational Functions 345
Problem Recognition Exercises: Polynomial and Rational Functions 368
Section 3.6 Polynomial and Rational Inequalities 369
Problem Recognition Exercises: Solving Equations and Inequalities 382
Section 3.7 Variation 383

Key Concepts 391
Review Exercises 394
Test 397
Cumulative Review Exercises 399

CHAPTER 4



Section 4.1 Inverse Functions 402 Section 4.2 Exponential Functions 414 Section 4.3 Logarithmic Functions 427 Problem Recognition Exercises: Analyzing Functions 442 Section 4.4 Properties of Logarithms 443 Section 4.5 Exponential and Logarithmic Equations and Applications 452 Section 4.6 Modeling with Exponential and Logarithmic Functions 466 Key Concepts 482 Review Exercises 485 Test 487 Cumulative Review Exercises 489

Exponential and Logarithmic Functions 401

Systems of Equations and Inequalities

### CHAPTER 5



Section 5.1	Systems of Linear Equations in Two Variables and Applications 492				
Section 5.2	Systems of Linear Equations in Three Variables and Applications 506				
Section 5.3	Partial Fraction Decomposition 517				
Section 5.4	Systems of Nonlinear Equations in Two Variables 527				
Section 5.5	Inequalities and Systems of Inequalities in Two Variables 536				
Problem Rec	cognition Exercises: Equations and Inequalities in Two				
Varia	ibles 547				
Section 5.6	Linear Programming 547				

Key Concepts 556 Review Exercises 558 Test 560 Cumulative Review Exercises 561

CHAPTER 6

### Matrices and Determinants and Applications 563



Section 6.1 Solving Systems of Linear Equations Using Matrices 564

Section 6.2 Inconsistent Systems and Dependent Equations 575

Section 6.3 Operations on Matrices 585

Section 6.4 Inverse Matrices and Matrix Equations 602

Section 6.5 Determinants and Cramer's Rule 612

Problem Recognition Exercises: Using Multiple Methods to Solve Systems of Linear Equations 625

Key Concepts 625 Review Exercises 627 Test 630 Cumulative Review Exercises 631

### CHAPTER 7

### Analytic Geometry 633



Section 7.1 The Ellipse 634 Section 7.2 The Hyperbola 651 Section 7.3 The Parabola 667

Problem Recognition Exercises: Comparing Equations of Conic Sections and the General Equation 680–681

Sequences, Series, Induction, and Probability 689

Key Concepts 682 Review Exercises 683 Test 685 Cumulative Review Exercises 687

CHAPTER 8



Section 8.1 Sequences and Series 690 Section 8.2 Arithmetic Sequences and Series 701 Section 8.3 Geometric Sequences and Series 712 Problem Recognition Exercises: Comparing Arithmetic and Geometric Sequences and Series 725 Section 8.4 Mathematical Induction 725 Section 8.5 The Binomial Theorem 732 Section 8.6 Principles of Counting 738 Section 8.7 Introduction to Probability 750 Key Concepts 764 Review Exercises 767 Test 770 Cumulative Review Exercises 772 Appendix A Additional Topics Appendix A-1 (Online only) Student Answer Appendix SA-1 Instructor Answer Appendix IA-1 (AIE only) Credits C-1 Index I-1

# **Key Features**

### **Clear, Precise Writing**

Because a diverse group of students take this course, Julie Miller has written this manuscript to use simple and accessible language. Through her friendly and engaging writing style, students are able to understand the material easily.

### **Exercise Sets**

The exercises at the end of each section are graded, varied, and carefully organized to maximize student learning:

- **Prerequisite Review Exercises** begin the section-level exercises and ensure that students have the foundational skills to complete the homework sets successfully.
- Concept Connections prompt students to review the vocabulary and key concepts presented in the section.
- Core Exercises are presented next and are grouped by objective. These exercises are linked to examples in the text and direct students to similar problems whose solutions have been stepped-out in detail.
- Mixed Exercises do *not* refer to specific examples so that students can dip into their mathematical toolkit and decide on the best technique to use.
- Write About It exercises are designed to emphasize mathematical language by asking students to explain important concepts.
- **Technology Connections** require the use of a graphing utility and are found at the end of exercise sets. They can be easily skipped for those who do not encourage the use of calculators.
- Expanding Your Skills Exercises challenge and broaden students' understanding of the material.

### **Problem Recognition Exercises**

**Problem Recognition Exercises** appear in strategic locations in each chapter of the text. These exercises provide students with an opportunity to synthesize multiple concepts and decide which problem-solving technique to apply to a given problem.

### **Examples**

- The examples in the textbook are stepped-out in detail with thorough annotations at the right explaining each step.
- Following each example is a similar **Skill Practice** exercise to engage students by practicing what they have just learned.
- For the instructor, references to an even-numbered exercise are provided next to each example. These exercises are highlighted with blue circles in the exercise sets and mirror the related examples. With increased demands on faculty time, this has been a popular feature that helps faculty write their lectures and develop their presentation of material. If an instructor presents all of the highlighted exercises, then each objective of that section of text will be covered.

### **Modeling and Applications**

One of the most important tools to motivate our students is to make the mathematics they learn meaningful in their lives. The textbook is filled with robust applications and numerous opportunities for mathematical modeling for those instructors looking to incorporate these features into their course.

### Callouts

Throughout the text, popular tools are included to highlight important ideas. These consist of:

- Tip boxes that offer additional insight to a concept or procedure.
- Avoiding Mistakes boxes that fend off common mistakes.
- Point of Interest boxes that offer interesting and historical mathematical facts.
- Instructor Notes to assist with lecture preparation.

### **Graphing Calculator Coverage**

Material is presented throughout the book illustrating how a graphing utility can be used to view a concept in a graphical manner. The goal of the calculator material is not to replace algebraic analysis, but rather, to enhance understanding with a visual approach. Graphing calculator examples are placed in self-contained boxes and may be skipped by instructors who choose not to implement the calculator. Similarly, the graphing calculator exercises are found at the end of the exercise sets and may also be easily skipped.

### **End-of-Chapter Materials**

The textbook has the following end-of-chapter materials for students to review before test time:

- Brief summary with references to key concepts. A detailed summary is located at www.mhhe.com/millercollegealgebra.
- Chapter review exercises.
- Chapter test.
- Cumulative review exercises. These exercises cover concepts in the current chapter as well as all preceding chapters.

### Updates to College Algebra:

- Two new sections, "Algebra for Calculus" and "Equations and Inequalities for Calculus", were added to Chapter R and Chapter 1. These additions provide STEM students an opportunity to connect current topics to what they'll learn in calculus.
- New "Prerequisite Review" exercises appear in every section. These allow students to ensure they have the necessary foundational skills to be successful in the section.
- Over 600 algorithmic homework exercises were added to Connect Math Hosted by ALEKS to ensure 90% textbook coverage.
- SmartBook content has been revised and enriched. For the first time, SmartBook is now available within Connect Math Hosted by ALEKS.
- 1200 new questions were added to the TestGen testbank.
- Graphing calculator screenshots have been updated to reflect the TI-84 Plus C.
- Section 2.7 for investigating increasing, decreasing, and constant behavior of a function now presents open intervals. This has also been updated in all of the digital materials accompanying the text.
- Sections R.1, R.2, 1.7 & 1.8 have been streamlined to provide greater clarity.
- New applications appear in Chapter 7 to provide students more real-world context for conic sections.
- Applications and real-world data have been updated, where appropriate, to ensure that content remains relevant and current.
- Wolfram Alpha Activities have been added to the Instructor's Resource Manual to allow students to explore college algebra in greater depth.

# Supplement Package

### Supplements for the Instructor

### **Author-Created Digital Media**

Digital assets were created exclusively by the author team to ensure that the author voice is present and consistent throughout the supplement package.

- The coauthor, Donna Gerken, ensures that each algorithm in the online homework has a stepped-out solution that matches the textbook's writing style.
- Julie Miller created **video content** (lecture videos, exercise videos, graphing calculator videos, and Excel videos) to give students access to classroom-like instruction by the author.
- Julie Miller constructed over 50 **dynamic math animations** to accompany the college algebra text. The animations are diverse in scope and give students an interactive approach to conceptual learning. The animated content illustrates difficult concepts by leveraging the use of on-screen movement where static images in the text may fall short. They are organized in Connect hosted by ALEKS by chapter and section.

The *Instructor's Resource Manual* (IRM) is a printable electronic supplement put together by the author team. The IRM includes Guided Lecture Notes, Classroom Activities using Wolfram Alpha, and Group Activities.

- The Guided Lecture Notes are keyed to the objectives in each section of the text. The notes step through the material with a series of questions and exercises that can be used in conjunction with lecture.
- The Classroom Activities using Wolfram Alpha promote active learning in the classroom by using a powerful online resource.
- A Group Activity is available for each chapter of the book to promote classroom discussion and collaboration.

The *Instructor's Solution Manual* provides comprehensive, worked-out solutions to all exercises in the section exercises, review exercises, problem recognition exercises, chapter tests, and cumulative reviews. The steps shown in the solutions match the style and methodology of solved examples in the textbook.

**TestGen** is a computerized test bank utilizing algorithmbased testing software to create customized exams quickly. This user-friendly program enables instructors to search for questions by topic, format, or difficulty level; to edit existing questions, or to add new ones; and to scramble questions and answer keys for multiple versions of a single test. Hundreds of text-specific, open-ended, and multiple-choice questions are included in the question bank.

### **Annotated Instructor's Edition**

- Answers to exercises appear adjacent to each exercise set, in a color used only for annotations.
- Instructors will find helpful notes within the margins to consider while teaching.
- References to even-numbered exercises appear in the margin next to each example for the instructor to use as Classroom Examples.

**Power Points** present key concepts and definitions with fully editable slides that follow the textbook. An instructor may project the slides in class or post to a website in an online course.

### Supplements for the Student

**Student Worksheets** including guided lecture notes that step through the key objectives and Problem Recognition Exercise worksheets.

### ALEKS<sup>®</sup> Prep for College Algebra

ALEKS Prep for College Algebra focuses on prerequisites and introductory material for College Algebra. These prep products can be used during the first 3 weeks of a course to prepare students for future success in the course and to increase retention and pass rates.

### Connect Math<sup>®</sup> Hosted by ALEKS

Connect Math Hosted by ALEKS Corp. is an exciting, new assignment and assessment ehomework platform. Starting with an easily viewable, intuitive interface, students will be able to access key information, complete homework assignments, and utilize an integrated, mediarich eBook.

**Smartbook**<sup>®</sup> is the first and only adaptive reading experience available for the higher education market. Powered by the intelligent and adaptive LearnSmart engine, Smart-Book facilitates the reading process by identifying what content a student knows and doesn't know. As a student reads, the material continously adapts to ensure the student is focused on the content he or she needs the most to close specific knowledge gaps.

Detailed Chapter Summaries are available at www.mhhe.com/millercollegealgebra.



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ALEKS is designed to meet the needs of today's students. A clean, modern, mobile-ready interface allows students to easily navigate their learning, track their progress and manage their assignments from anywhere.

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<sup>44</sup>I evaluated many different options, and ALEKS provided, by far, the best cycle of assessment and learning that allows for individualized instructional paths . . . no other program matches ALEKS.<sup>37</sup> —Professor Eliza Gallagher, Clemson University, SC

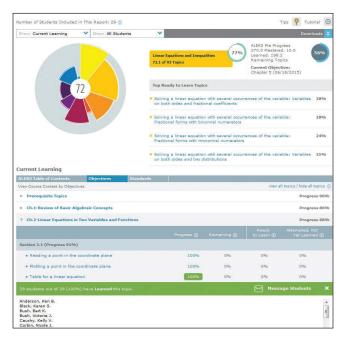
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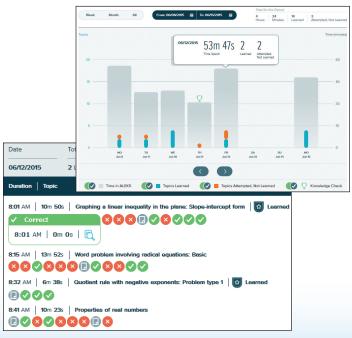


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Use this data to inform your teaching, group students based on similar knowledge levels, and shape a meaningful learning experience for your students.

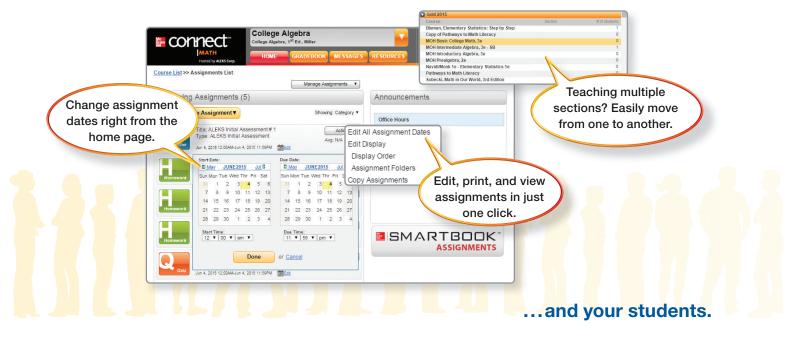


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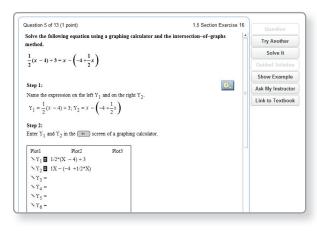
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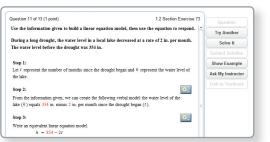
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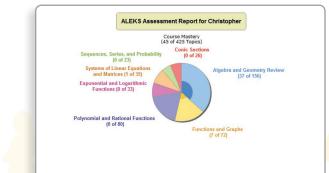
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Reports are also available to both students and instructors that track progress and show each student's strengths and weaknesses. What does this mean for you? Teach a more informed classroom and provide more personalized guidance.

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	SECTION R.2	Models, Algebraic Expressions, and Properties of Real Numbers				
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Put in order, from top to bottom, the steps required for finding the inverse of		munication and a new commercial $A_{BP(1)}^{(n)}$ market. So who spends the most on <b>Figure 8.3</b> cellular service? Figure <b>8.5</b> shows the service of the service service service services ( <i>Source:</i> <b>1.5</b> most experiments, $E$ (in oblications which gere) From the figure, the annual expenditure for cellular services can be approximated by the formula or algebraic model):				
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# Our Commitment to Market Development and Accuracy

### Acknowledgments:

Paramount to the development of *College Algebra* was the invaluable feedback provided by the instructors from around the country who reviewed the manuscript or attended a market development event over the course of the several years the text was in development.

### A Special Thanks to All of the Event Attendees Who Helped Shape College Algebra.

Focus groups and symposia were conducted with instructors from around the country to provide feedback to editors and the authors and ensure the direction of the text was meeting the needs of students and instructors.

Halina Adamska, Broward College-Central Mary Beth Angeline, West Virginia University Colleen Beaudoin, University of Tampa Rachel Black, Central New Mexico Community College Tony Bower, Saint Phillips College Bowen Brawner, Tarleton State University Denise Brown, Collin College Wyatt Bryant, Tarleton State University Christine Bush, Palm Beach State College Michelle Carmel, Broward College–North Lydia Casas, Saint Phillips College Carlos Corona, San Antonio College Deric Davenport, Pikes Peak Community College Alan Dinwiddie, Front Range Community College–Fort Collins Marion Foster, Houston Community College Charles Gabi, Houston Community College Jason Geary, Harper College Steve Gonzales, Northwest Vista College Jeffrey Guild, Broward-Central Campus Craig Hardesty, Hillsborough Community College–Southshore Lori Hodges, University of New Orleans Carolyn Horseman, Polk College Kimber Kaushik, Houston Community College Lynette Kenyon, Collin College-Plano Daniel Kernler, Elgin Community College Sharon Kobrin, Broward-Central Campus Daniel Kopsas, Ozarks Technical Community College Danny Lau, University of North Georgia Andreas Lazari, Valdosta State University

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# **Applications Index**

### **Agriculture & Gardening**

Corn plants per acre for maximum yield, 398 Costs for farmer to run tractor, 426 Crop acreage and maximum profits, 556 Dimensions and area of corrals/chicken coops, 293 297 394 Dimensions and area of garden in yard, 297 Dimensions of garden based on area, 380 Dimensions of triangular portions of garden, 163 Fencing and pens enclosed by farmer, 132 Height of tree and age, 481 Length of garden from footage of fencing used, 155 Nursery's inventory and profits, 555 Plant fertilizer makeup, 515 Seeds selected from package, good versus defective, 749 Sunflower height, 16

### **Animals & Pets**

Animal's mass in relation to tidal volume, 413
Animal's mass in relation to weight of heart, 396
Deer population, 94, 101, 488
Dog's "accident" on rug probability, 763
Gestation and longevity for selected animals, 225, 227
Progression of kitten's weight, 709
Puppy's weight increase in days/months after adoption, 224–226
Rabbit population in wildlife area, 398
Spay/neuter costs for shelter, 553
Top speed of car to avoid hitting deer, 131
Veterinarian X-ray machine resale value, 426

### Biology

Age of one person in terms of another's, 78 Bacteria population in culture, 296, 297, 380, 470-471, 478, 488, 535 Bass population in lake, 101, 487 Blood alcohol level and rate of change, 203-204 Concentration of drug in bloodstream, 366, 382, 527, 534 Deer population, 94, 101, 488 Gender probability, 749, 758, 760 Gestation and longevity for selected animals, 225, 227 Girl's average height by age and projections, 226 Girl's height and weight from age 2 to 10, 225 Height of plant versus time, 143 Hemoglobin level for adult female, 154 Leptin concentration versus body fat, 132 Pea plant color probabilities (Mendel), 761 Percentage of drug in bloodstream versus time, 143 Probability of being left-handed, 394 Symmetry of bird, human face and flower, 243 Turtle population in pond, 160

### **Business**

Advertising campaign and new sales, 465, 574 Aluminum and cylindrical drink mix container, 382 Amount of counterfeit money "spent," 722 Arrangement of commercials during half-hour show, 749 Business startup and simple interest, 100 Car prices, 598 Change in T-shirt cost from manufacturer, 251 Cleaning company's average cost per house call, 361 Companies' costs, revenue and break-even point, 500, 503, 504 Company expenses for one year and subsequent years, 700 Company trucks' operational costs, 553, 555 Concession stand sales, 584 Cookbook sales and relation to price, 389 Cookie maker's costs, revenue and profits, 224 Cost of full- and part-time employees, 548, 550 Costs for business stationery, 273 Customer service wait-time probability, 772 Dance studio's costs, revenue and profits for private lessons, 280 Decreased dimensions and volume of cereal box, 344 Delivery truck route possibilities, 748 Diner's profits on tea and coffee, 553 Donut shop profits, 560 Fishing boat's excursion costs per month, 558 Food market's monthly sales, 411 Gas station's weekend profits and weekly revenue, 599 Inflation and company's monthly costs, 481 Inheritance money spent and respent, 722 Items/amount sold and total revenue, 594, 598, 599,628 Labor costs, 555, 599 Lawn company's costs, revenue and profits for maintenance calls, 224, 500 Lemonade vendor's costs, revenue and profits, 217-218 Manufacturers' production costs and profits, 554, 555 Maximum profit for companies, 296, 551-552, 554, 555 Measurement error in dispensing bottled juice, 151-152 Merchant price for patio set, 102 New book sales trend, 481 New product sales, 479 Number of handshakes at meeting, 800 Number of possible customer service survey responses, 747, 771 Power company and costs for air pollutant control. 366 Printing company's average costs, 365 Selling price of home, 516 Sports trainer's average costs, 365, 396 Supply and demand (movie tickets, cookbooks), 504 Tax rebate money spent and respent, 718, 722 Ticket types sold, 584 Time to prepare orders for shipping, 144 Time to typeset manuscript, 160

Bookstore price for textbook, 102

Business loans, 573

Tourism value to local economy, 722, 768, 771 Tractor resale value, 426, 721

X-ray machine resale value, 426

### Chemistry

Acid mixtures, 160, 499, 512, 558 Antifreeze mixture, 100, 163, 502, 503 Bleach mixture, 96, 498–499 Ethanol and gasoline mixture, 100 Fertilizer mixture, 100, 102 pH levels, 440, 465, 486 Saline solution mixture, 100, 502 Water evaporation and salt solution, 102

### Construction

Amount of kitchen tile needed and costs, 103 Amount of wire left based on wire used, 196 Bridge arch height, 684 Circular cross section of vent pipe with roof, 649 Concrete mixture, 100, 101, 160 Cost of roof repairs versus costs new roof, 102 Dimensions of length and width of rectangular part of house front, 130 Dimensions of triangular ends of patio, 130 Easement width on buildable lot, 102 Elliptical concrete pipe design, 684 Floor dimensions, 533 Gutter spout dimensions and water volume, 126 Lengths of roof truss triangles, 131 Location of foci on semielliptical window, 647 Location of foci to make elliptical table, 647 Maximum volume of solar oven, 314 Measurement error in cutting board, 152 Measurements of bridge cables, 679, 685, 686 New roof and skylights costs, 75 Parking lot dimensions, 292-293 Pitch of a roof, 208 Plywood costs, 559 Pool's water volume during filling, 157 Porch dimensions and carpeting costs for, 103 Power drill cost, 278 Rates of lumber cut, 515 Roof rafter length, 36 Semiellipse of road tunnel, 643, 686 Slope of storm drainage pipe, 208 Solar water heater's tube, 678 Time for pump(s) to fill pool, 101 Time/rate for pump(s) to drain pond, 160, 573 Time to install plumbing fixtures, 144 Velocity of fluid through drainage pipe, 298 Water volume carried by gutter, 297 Wind pressure on wall, 398 Wooden beam size and strength, 390

### **Consumer Spending**

Amounts borrowed, 627 Apartment rental costs, 17 Average electric bills, 703 Book cost based on markup after publisher cost, 193 Car financing, 194 Car loans and interest, 424, 441, 485 Car prices, 598 Car rental costs, 389, 552 Cell phone costs based on age of user, 394 Cell phone plan costs, 216, 258, 599 City parking garage costs, 223 Cost of roof repairs versus costs new roof, 102 Cost to carpet room based on size, 390 Cost to download music from website, 268 Cost to lease new car versus buying used car, 82, 84-85 Decreased dimensions and volume of cereal box, 344 Dining room table prices, with tax, 629 Federal income tax, 261 First-class postage costs, 258 Grocery store payment types and gender, 772 Gym charges and fees, 160 Health insurance coverage probability, 772 Home health care expenditures, 92 Home loan and interest, 441 Home purchase price, 574 Home value and appreciation over time, 721 Hotel room charges and fees, 17, 155 Kitchen tile costs based on length and width of room, 390 Lawn mower sale price, 13 Lawn sodding costs, 162 New roof and skylights costs, 75 Online ticket purchases for dance show, 273 Outdoor grill sale price, 16 Phone card minutes left, 196 Power company charges per kilowatt-hour, 17 Power drill cost, 278 Projected salary increases, 92 Property taxes, 101, 223, 413 Restaurant bill and tipping, 12, 16, 193 Retirement planning, 424, 463, 546, 800 Selling price of home, 516 Storage unit rental costs, 85 Student loans and simple interest, 100, 164, 503 Subway ride costs and savings with MetroCard, 92 Television services spending, 219 Tiling project costs, 771 Toll costs and discounts for, 92 Vehicle depreciation, 37, 143, 482 Video games spending per person, 194 Watercolor paint price at online shop, 269 Water utility costs, 17

### **Distance/Speed/Time**

- Acceleration of rocket versus time after launch, 314, 398 Airplane's altitude, speed and distance, 413 Airplanes' average speed, 101, 141, 154, 163 Average running and biking speed during biathlon, 141 Average speed of car in nice weather versus in thunderstorm, 141 Average speed of highway versus city driving, 97 Average speed of plane's round trip, 70 Biathlon and distance of route, 101 Braking distance and speed, 131, 161, 298, 380, 389 Car's acceleration and deceleration, 257, 274 Car's velocity, 94 Commute distance based on round trip and speed, 160 Distance between Earth and its moon at aphelion, 648
- Distance between Mars and Sun at aphelion, 644 Distance between Neptune and Sun at
- perihelion, 686 Distance between Pluto and Sun from eccentricity of Pluto, 644

Distance between Saturn and Sun at aphelion, 648 Distance from baseball diamond home plate to second base, 131 Distance from Earth to Barnard's Star, 23 Distance of bike ride and time, 193 Distance of drive from Daytona Beach to Miami, 193 Distance of earthquake epicenter from seismograph, 102 Distance of McNaught comet from Sun, 664 Distance of object in free fall over time, 710 Distance to fire from observation platforms, 175.182 Distance traveled by rolling/bouncing ball over time, 710, 723 Gas mileage at 60 mph, 279-281 Gas mileage compared with speed, 131, 296, 297 Gas mileage in city and on highway, 17, 94 Height and horizontal distance of water from firefighter hose, 296 Height of stone thrown from cliff, 291 Height of thrown football and time to reach receiver, 291 Impact velocity of dropped object, 16, 143 Marina's distance up shoreline, 144 Maximum height and length of long jump, 296 Maximum height of launched item, 772 Motorist's average speed, 380 Observer's eye level above ground, 143 Orbits of Halley's Comet and Earth, 648 Point of contact of kicked ball/rock, 534 Radar detector accuracy, 155 Rate of work done, 98, 99 Revolutions of bike wheel and distance traveled, 273, 389 Riverboat travel upstream and downstream, 499-500 Runners' speeds, 503, 560 Running and biking speeds, 97, 505 School commuting distance, 101 Sled acceleration, 257 Speeding ticket cost, 216 Speed of boat in still water, 134-135, 141 Speed of current versus speed of fishing boat, 503 Speed of moving sidewalk versus speed of walker, 503 Speed of two boats, 160 Swimming and running speeds, 505 Time for car to pass truck to be certain miles ahead, 154 Time for runners to cover quarter-mile track, 101 Time/rate for pump(s) to drain pond, 160, 573 Time to prepare orders for shipping, 144 Time to typeset manuscript, 160 Top speed of car to avoid hitting deer, 131 Velocity of fluid through drainage pipe, 298 Vertical height of football from ground after kick and time to reach, 132 Vertical height of soccer ball from ground and time to reach, 164

### Education

Arrangement of books on shelf, 750 Book cost based on markup after publisher cost, 193 Bookstore price for textbook, 102 Cafeteria lineup possibilities, 749 College application increase, 411 College credit-hour costs, 17, 91 Course selection possibilities, 769 Drama class participation possibilities, 769 Elementary vocabulary lesson and testing, 465 Exam question probability, 771 Final exam grade probability, 761 Final exam scores needed, 144, 151, 154 Multiple-choice test and probabilities, 762, 769 Number of ways students selected for student government/committee positions, 742, 744-745 Possible ways to misspell a word, 769, 771 Public college enrollment and projected enrollment, 225, 227 School commuting distance, 101 Selection of students for scholarships, 742-744, 764 Selection of students in course, 760 Selection possibilities of students to perform in play/dance, 748 Student averages and class absences, 102 Student loans and simple interest, 100, 164, 503 Student work-study earnings, 154 Study hours for various courses, 543, 545 Summer reading book selection possibilities, 749 Test answer possibilities, 740-741, 747 Tutoring hours and income, 554, 559 Weighted exam scores, 598

### **Employment**

Employee tasks possibilities, 749 Hospital employee ID codes, 747 Hourly wages, 503 Number of workers and time to complete job, 389 Pharmaceutical sales job's salary and commission, 92 Projected salary increases, 92 Rate of work done, 98, 99 Salaries of two jobs over time compared, 724 Salary and commission comparison between two jobs, 155 Salary and total income with annual raises, 707-708 Salary of one person in terms of another's, 75 Salesperson's weekly/monthly salary with commissions, 223, 250-251, 258, 552, 768 Soldier selection possibilities, 749 Student work-study earnings, 154 Weekly salary, 100, 503

### Environment

Atmospheric pressure and altitude, 425 Costs to remove waste from polluted river, 366 Distance between hikers in park, 175 Distance of earthquake epicenter from seismograph, 102 Distance to fire from observation platforms, 175, 182 Earthquake magnitude/intensity, 437, 439, 465 Geological study areas and earthquake epicenter, 182 Height of Pacific Ocean volcano since 1960, 280 Height of plant versus time, 143 Hurricane wind speed and barometric pressure, 224, 226, 413 Ocean waves and average rate of change in speed, 210 Pollution based on number of people, 389 Power company and costs for air pollutant control, 366 Turtle population in pond, 160 Water level in Everglades, 413, 702-703 Water level in retention pond, 223, 258, 259

Weight of body above Earth surface, 398 Where earthquake could be felt, 130, 546

### **Finances & Investments**

Amount of counterfeit money "spent," 722 Annuity value, 718-720, 722-723, 768, 771 Bonds, interest and yields, 386, 389, 463 Certificates of deposit and simple interest, 13, 100 Compound interest, 210, 279, 420, 424, 463, 476, 485, 488, 535 Federal income tax, 261 Inflation and buying power, 425 Investment and interest earnings, 274, 424, 476, 562 Investment in bond fund and yield, 452-453, 460-461 Investment rate of return, 468, 469, 476, 487, 488 Loan payments, 482 Money market funds, 463 Mutual fund investments, 512, 515 Principal investment amounts, 535, 558, 573 Property taxes, 101, 223, 413 Retirement planning, 424, 463, 546, 800 Simple interest, 13, 95, 100, 103, 387, 389, 424, 485, 503, 573 Stock and mutual fund investments, 103, 160, 515 Stock fund and rate of return, 476 Stock investments, 560 Tax rebate money spent and respent, 718, 722 Total amount earned, 723 Tractor resale value, 426, 721 Treasury notes, bonds and simple interest, 100, 160

### **Food & Nutrition**

Almond croissant purchase in France, 273 Caffeine and biological half-life, 464 Calcium content, 558 Cookbook sales and relation to price, 389 Cooling rate of cake/pie from oven, 426, 464 Dinner menu choice possibilities at hospital, 747 Ham and number of people it will serve, 389 Hamburgers' caloric and cholesterol content, 225, 227 Ice cream fat content, 503 Maximum profit for baker, 551 Nut mixture, 560 Prices for hot drinks, with tax, 598 Probability of certain cookies selected from box, 760 Protein powder content, 560, 561 Restaurant bill and tipping, 12, 16, 193 Sodium content in chips and soda, 503 Solar cooker pot placement, 676, 678 Turkey baking time, 37

### **History & Landmarks**

Arches of WW II airship hangars, 685 Elliptical boundary and eccentricity of Washington's Ellipse, 648 Roman Coliseum's inner and outer ellipse, 648

### **Hobbies & Entertainment**

Bingo game attendance, 283 Chess tournament matches played, 748 College theater tickets, 546 Cost to download music from website, 268 Dance lesson demonstration possibilities, 748 Dance studio charges and fees, 160 Days to read book, 771 Distance of bike ride and time, 193 DVD/CD selection probabilities, 764, 769 Elliptical pool table, 650 Family's time spent at two Disney parks, 543 Film festival award possibilities, 748 Fireworks vertical height, speed and visibility, 129, 161, 380 Frequencies of piano notes, 723 Location of foci for boomerang, 664 Marble color probabilities, 751 Number of possible lottery combinations, 745, 748 Number of song downloads, 99 Number of theater seats, 711 Online ticket purchases for dance show, 273 Poetry contest winning possibilities, 743 Possible arrangement of songs by DJ, 769 Probability of certain cards drawn from deck, 755-756, 761-762, 764, 770, 772, 774 Probability of winning lottery (various circumstances), 760, 770 Raffle winning possibilities, 771 Rock concert's intensity and loudness, 461 Rock songs versus country songs on playlist, 546 Sculpture placement in museum, 642-643 Shadow box dimensions and area, 297 Speed of racing canoe, 390 Theater ticket pricing, 515 Thrown ball's speed and vertical position, 396 Time for thrown bread to reach George in Seinfeld episode, 132 Toy rocket's vertical position and time, 128-129, 314, 376-377 Video game players' positions and speed, 175

Video games spending per person, 194 Watercolor paint price at online shop, 269

### Home & Family

Arrangement possibilities for people in photo, 748,774 Defective lightbulb probability, 770 Elliptical rug from rectangular carpet piece, 647 Garage door remote sequence possibilities, 747 Lawn mowing time, 101 Number of outfit possibilities, 747, 771 Palindrome possibilities, 749 Plumbing repairs, 102 Possible boy/girl sequences for couple, 749 Probability of births being twins/not twins, 760 Probability of children in family being all boys/ all girls, 758 Probability of guessing alarm's 4-digit code correctly, 762 Selecting batteries, good versus dead, 749, 760 Sock color selection probability, 751 Three-digit number combinations for lock/code, 749, 769 Time for hose to fill aboveground pool, 163 Vacuuming time, 101

### Measurements

Aluminum and cylindrical drink mix container, 382
Aquarium dimensions, 534
Chopsticks in terms of timber used, 79
Dimensions of cloth cut at textile factory, 161
Dimensions of "golden rectangle," using "golden ratio," 132
Dimensions of length and width of rectangular part of house front, 130
Dimensions of sail on boat, 127, 131
Dimensions of sheet of cardboard from box, 126, 130

Dimensions of TV screen, 36, 161, 531-532, 560 Floor dimensions, 533 Grocery store sign dimensions, 533 Height of light post from height of man's shadow, 102, 157 Height of Washington Monument, 102 Length of sides of octagonal stained glass window, 132 Length of triangle's shortest side, 155 Margin of error in refrigerator temperature, 155 Measurement differences among cereal boxes, 155 Measurement error in cutting board, 152 Measurement error in dispensing bottled juice, 151-152 Number of cups in each row of pyramid, 711 Number of theater seats, 711 Quilt dimensions from its area, 380 Radius of area to be watered, 130 Radius of underground gasoline storage tank, 343 Rental truck dimensions, 344, 533 Rug dimensions, 532 Swings of a pendulum, 390, 768 Tent dimensions, 343 Window dimensions, 533

### **Medicine & Health**

Aspheric eyeglass lenses, 664 Average heart rate, 26 Average newborn weight, 23 Bacteria population in culture, 296, 297, 380, 470-471, 478, 488, 535 Blood pressure probability, by age and smoker/ nonsmoker, 770 Blood type probabilities, 763 Blood type transfusion-matching probabilities, 763 Body mass index, 389 Body temperature in Fahrenheit versus Celsius, 155 Breast cancer survival probability, 762 Cholera epidemic and deaths, 465 Concentration of drug in bloodstream, 70, 366, 382, 527, 534 Doctor visits in relation to patient's ages, 398 Ebola virus, 79, 480 Flu outbreak and new cases, 210, 721 Girl's height and weight from age 2 to 10, 225 Heart surgery mortality rate, 761 Hemoglobin level for adult female, 154 HIV particle size, 25 Home health care expenditures, 92 Kidney stone position in lithotripsy procedure, 647 Leptin concentration versus body fat, 132 Mean blood volume, 25 Medicine dosages and patients' weight, 384, 385-386, 389 New AIDS cases in United States, 314 Number of red blood cells, 26, 76 Participants in drug and alcohol rehabilitation program, 709 Percentage of drug in bloodstream versus time, 143 Pharmaceutical sales job's salary and commission, 92 Prescription drug expenditures per capita, 92 Probability of catching a cold, 759 Probability of cholesterol level by age, 762 Radioactive substances used in health care, 464, 478, 485-486, 534, 631 Recommended heart rate and age, 12 Red blood cell size, 26 Resale value of medical device, 721 Saline solution mixture, 100, 502

Salmonella bacteria size, 23 Sounds and hearing impairment, 465 Sounds and pain-causing intensity and loudness, 461 Systolic blood pressure by age, 219, 220–221 Total cholesterol and LDL level, 101, 163

### **Politics**

XX

Committee formation possibilities, 748 Number of Republicans and Democrats in U.S. Senate, 99, 101 Political party probability, 761 Poll results versus actual percentage of votes received, 155 Senate committee member choices, 748

### Science

Area of picture projected on wall, 389 Atmospheric pressure and altitude, 425 Atomic particles, 664 Bulb in parabolic mirror of car light/flashlight, 676 Caffeine and biological half-life, 464 Carbon-14 dating, 471-472, 477, 487 Cooling rate of cake/pie from oven, 426, 464 Cooling rate of water after heater shut off, 426 Depth of water (in oceans and lakes) and intensity of light, 487 Diameter of nuclear power cooling tower, 664 Distance between Earth and its moon at aphelion, 648 Distance between Jupiter and Sun at aphelion, 684 Distance between Mars and Sun at aphelion, 644 Distance between Neptune and Sun at perihelion, 686 Distance between Pluto and Sun from eccentricity of Pluto, 644 Distance between Saturn and Sun at aphelion, 648 Distance from Earth to Barnard's Star, 23 Distance from Earth to Proxima Centauri, 26 Distance of earthquake epicenter from seismograph, 102 Distance of McNaught comet from Sun, 664 Distance of object in free fall over time, 710 Earthquake magnitude/intensity, 437, 439, 465 Earth's mean surface temperature, 37 Electric current based on voltage and resistance, 389 Electric power based on current and resistance, 397 Elliptical curve of lightbulb, 647 Equilibrium forces, 505 Fahrenheit to Celsius temperature conversions, 102 Freezing temperature versus time, 70, 380 Frequencies of piano notes, 723 Geological study areas and earthquake epicenter, 182 Gravitational force and planets, 27, 384 Half-life of radioactive elements, 421, 425, 464, 478, 485-486, 534 Hurricane and kinetic energy, 387 Initial velocity and acceleration, 709 Kepler's third law, 391 Lightbulb intensity, 390 Mean distance between Earth and Sun, 25 Microphone placements to locate shooter, 663 Molecules in water drop, 26 Orbits of Halley's and Hale-Bopp comets, 648 Orbits of Halley's Comet and Earth, 648 Radiation intensity in relation to distance from source, 391 Resistance in parallel circuits, 365-366

Satellite dish receiver placement, 674-676 Satellite travel in 24-hour period, 24 Sound frequencies, 366 Sound loudness and distance from source, 386 Sounds heard by two people in different positions, 660, 684, 686 Sounds' intensity, 440, 461 Speed of light, 25 Star's mean surface temperature, 37 Steel welding and temperature, 464 Swings of a pendulum, 390, 768 Telescopes' parabolic mirrors, 678-679 Temperatures on conducting plate, 611 Vertical velocity of dropped object, 709 Vinegar and water as cleaning agent, 503 Weight of body above Earth surface, 398 "whispering gallery" positions, 647

### **Sports & Recreation**

Age limits for playing in tennis tournament, 154 Arena seating and ticket sales, 558 Average running and biking speed during biathlon, 141 Baseball player's probability of getting hits/not getting hits, 758, 760, 770 Basketball player possibilities to start game, 749 Basketball player's rebound jump, 380 Basketball player's shots and throws, 515 Biathlon and distance of route, 101 Bowler's handicap based on average scores, 155 Calories burned during exercise, 553, 599, 631 Coin toss probabilities, 724, 749, 758, 762 Dice rolling probabilities, 753, 760, 762, 770, 772 Dimensions of sail on boat, 127, 131 Distance between hikers in park, 175 Distance from baseball home plate to second base, 131 Distance traveled by rolling/bouncing ball over time, 710, 723 Force to break board in karate, 396 Golf hitting distance, 154 Golf score needed, 164 Gym charges and fees, 160 Gymnast's competition scores, 154 Height of thrown football and time to reach receiver, 291 Horse race winning possibilities, 743, 748, 750 Maximum height and length of long jump, 296 Michael Jordan's height above ground when jumping, 132 Number of men and women at motorcycle rally, 99 Number of players in round-robin tennis tournament, 131 Number of ways softball team can be formed, 746 Olympic athletes and medals won, 278 Probability of making all free throws in game, 762 Race car finish possibilities, 769 Radius and weight of exercise ball, 396 Record-setting table tennis rally, 25 Roller coaster height, based on time, 259 Roulette outcome probabilities, 752, 760 Runners' speeds, 503, 560 Running and biking speeds, 97, 505 Seesaw and equilibrium of, 104 Shoreline destination for canoe versus time, 144 Sled acceleration, 257 Slot machine outcome probability, 763 Softball batting order possibilities, 750 Speed of boat in still water, 134-135, 141

Speed of current versus speed of fishing boat, 503 Sporting goods store's inventory and profits, 555 Sports trainer's average costs, 365, 396 Swimming and running speeds, 505 Tennis tournament match possibilities, 748 Time for runners to cover quarter-mile track, 101 Time spent on treadmill after incremental increases, 709 Time to reach record-setting vertical jump, 132 Touchdown passes thrown, 16 Vertical height of football from ground after kick and time to reach, 132 Vertical height of soccer ball from ground and time to reach, 164 Video game scores, 100 Width of border around tennis court, 102 Wimbledon match probability, 762 Winning carnival game probability, 764

### Statistics/Demographics

Jury pool makeup probabilities, 760, 771 New AIDS cases in United States, 314 Number of ancestors over 12 generations, 724 Number of male versus female police officers, 160 Number of men and women in jury pool, 99 Petroleum usage in U.S., 26 Population changes (of various towns, states, and countries), 274, 425, 469-470, 477, 479, 482, 487, 773 Population density, 24 Prescription drug expenditures per capita, 92 Probability of being over 60 in China, 761 Probability of births being twins/not twins, 760 Probability of one-year survival at various ages, 750, 753, 770 Probability of selecting two women, two men, 774 Social Security number possibilities, 749 U.S. population, 425, 478 **Technology & Electronics** Cell phone costs based on age of user, 394

Cell phone plan costs, 216, 258, 599 Cell tower signal boundary, 182 Computer byte arrangements, 747 Computer password possibilities, 740, 747 Computer storage, 26 Computer virus, 479 Dimensions of TV screen, 36, 161, 531-532, 560 Length and width and pixels per inch of cell phone display area, 131 Length and width of computer display area, 131, 161 Number of songs stored on device, 26 Number of tablets sold and total revenue and profit, 598 Radio station call letter possibilities, 747 Rock songs versus country songs on playlist, 546 Total unread emails, 709 Video-sharing capacity on web page, 26 Website visitors, 488

### **Transportation & Travel**

Airline oversold seat selections, 749 Airplane location based on radio signals, 666 Airplane's altitude, speed, and distance, 413 Airplanes' average speed, 101, 141, 154, 163 Average speed of car in nice weather versus in thunderstorm, 141

Average speed of highway versus city driving, 97

Average speed of plane's round trip, 70 Braking distance and speed, 131, 161, 298, 389 Car, skids and curve of road, 384 Car rental costs based on miles driven, 389 Car's acceleration and deceleration, 247, 257, 274 Car seating arrangement possibilities, 749 Car's velocity, 94 City miles driven in hybrid car based on gas mileage, 160 City parking garage costs, 223 Commute distance based on round trip and speed, 160 Cost to lease new car versus buying used car, 82 Diameter of flight control tower, 684 Dimensions of truck cargo space, 130 Distance of bike ride and time, 193 Distance of drive from Daytona Beach to Miami, 193 Gas mileage, 17, 94, 131, 279-281, 296, 297, 516 Gas mileage and vehicle weight, 516 Limits on plane's altitude, 162 Marina's distance up shoreline, 144 Miles driven by truck, 505 Miles driven in city versus on highway, 505 Motorist's average speed, 380

Number of possible license plates, 747 Number of routes to travel, 769 Number of small versus large rental buses for college, 548-550 Probability of being killed in vehicle crash, 771 Probability of shortage of airline seats on certain route, 763 Radar detector accuracy, 155 Radar range of ship, 182 Red traffic light probability, 762 Rental truck dimensions, 344, 533 Revolutions of bike wheel and distance traveled, 273.389 Riverboat travel upstream and downstream, 499-500 School commuting distance, 101 Ship location and radio signal locations on shore, 663 Shoreline destination for canoe versus time, 144 Slope of hill, 208 Sounds' intensity (jet, traffic, motorcycle), 440 Speeding ticket cost, 216 Speed of boat in still water, 134-135, 141 Speed of moving sidewalk versus speed of walker, 503

Speed of two boats, 160 Subway ride costs and savings with MetroCard, 92 Time for car to pass truck to be certain miles ahead, 154 Toll costs and discounts for, 92 Top speed of car to avoid hitting deer, 131 Traffic flow rates, 580–581, 584, 628, 631 Travel and cost per night, 573 Travel timing for two ships, 132 Vehicle depreciation, 37, 143, 482

### Weather

Average speed of car in nice weather versus in thunderstorm, 141
Daily high and low temperatures, 274
Depth of snow and height of pole, 102
Hurricane and kinetic energy, 387
Hurricane wind speed and barometric pressure, 224, 226, 413
Monthly rainfall amounts in Miami, 162
Snow needed to exceed monthly average snowfall, 151
Temperatures and average rate of change, 210
Wind pressure on wall, 398

# R

# **Review of Prerequisites**

### **Chapter Outline**

- R.1 Sets and the Real Number Line 2
- R.2 Integer Exponents and Scientific Notation 18
- **R.3** Rational Exponents and Radicals 27
- **R.4** Polynomials and Multiplication of Radicals 38
- Problem Recognition Exercises: Simplifying Algebraic Expressions 47
- **R.5** Factoring 47
- R.6 Rational Expressions and More Operations on Radicals 59

Algebra for Calculus 72

A thletes know that in order to optimize their performance they need to pace themselves and be mindful of their target heart rate. For example, a 25-year-old with a maximum heart rate of 195 beats per minute should strive for a target heart rate zone of between 98 and 166 beats per minute. This correlates to between 50% and 85% of the individual's maximum heart rate (Source: American Heart Association, www.americanheart.org). The mathematics involved in finding maximum heart rate and an individual's target heart rate zone use a linear model relating age and resting heart rate. An introduction to modeling is presented here in Chapter R along with the standard order of operations used to carry out these calculations.

Chapter R reviews skills and concepts required for success in college algebra. Just as an athlete must first learn the basics of a sport and build endurance and speed, a student studying mathematics must focus on necessary basic skills to prepare for the challenge ahead. Preparation for algebra is comparable to an athlete preparing for a sporting event. Putting the time and effort into the basics here in Chapter R will be your foundation for success in later chapters.

### **SECTION R.1**

### OBJECTIVES

- 1. Identify Subsets of the Set of Real Numbers
- 2. Use Inequality Symbols and Interval Notation
- 3. Find the Union and Intersection of Sets
- 4. Evaluate Absolute Value Expressions
- 5. Use Absolute Value to Represent Distance
- 6. Apply the Order of Operations
- 7. Simplify Algebraic Expressions
- 8. Write Algebraic Models

### Sets and the Real Number Line

### 1. Identify Subsets of the Set of Real Numbers

A hybrid vehicle gets 48 mpg in city driving and 52 mpg on the highway. The formula  $A = \frac{1}{48}c + \frac{1}{52}h$  gives the amount of gas A (in gal) for c miles of city driving and h miles

of highway driving. In the formula, *A*, *c*, and *h* are called **variables** and these represent values that are subject to change. The values  $\frac{1}{48}$  and  $\frac{1}{52}$  are called **constants** because their values do not change in the formula.

For a trip from Houston, Texas, to Dallas, Texas, a motorist travels 36 mi of city driving and 91 mi of highway driving. The amount of fuel used by this hybrid vehicle is given by

$$A = \frac{1}{48}(36) + \frac{1}{52}(91)$$
  
= 2.5 gal

The numbers used in day-to-day life such as those used to determine fuel consumption come from the set of real numbers, denoted by  $\mathbb{R}$ . A **set** is a collection of items called **elements.** The braces { and } are used to enclose the elements of a set. For example, {gold, silver, bronze} represents the set of medals awarded to the top three finishers in an Olympic event. A set that contains no elements is called the **empty set** (or **null set**) and is denoted by { } or  $\emptyset$ .

When referring to individual elements of a set, the symbol  $\in$  means "is an element of," and the symbol  $\notin$  means "is not an element of." For example,

 $5 \in \{1, 3, 5, 7\}$  is read as "5 is an element of the set of elements 1, 3, 5, and 7."  $6 \notin \{1, 3, 5, 7\}$  is read as "6 is *not* an element of the set of elements 1, 3, 5, and 7."

A set can be defined in several ways. Listing the elements in a set within braces is called the **roster method**. Using the roster method, the set of the even numbers between 0 and 10 is represented by  $\{2, 4, 6, 8\}$ . Another method to define this set is by using **set-builder notation**. This uses a description of the elements of the set. For example,

 $\{x | x \text{ is an even number between 0 and 10}\}$ 



x is an even number between 0 and 10

In our study of college algebra, we will often refer to several important **subsets** (parts of) the set of real numbers (Table R-1).

**Table R-1** Subsets of the Set of Real Numbers,  $\mathbb{R}$ 

Set	Definition
Natural numbers, ℕ	{1, 2, 3,}
Whole numbers, $\mathbb{W}$	$\{0, 1, 2, 3, \ldots\}$
Integers, Z	$\{\dots, -3, -2, -1, 0, 1, 2, 3, \dots\}$
Rational numbers, Q	<ul> <li>{ p/q   p, q ∈ Z and q ≠ 0 }</li> <li>Rational numbers can be expressed as a ratio of integers where the denominator is not zero. Examples: -<sup>6</sup>/<sub>11</sub> (ratio of -6 and 11) and 9 (ratio of 9 and 1).</li> <li>All terminating and repeating decimals are rational numbers. Examples: 0.71 (ratio of 71 and 100), 0.6 = 0.666 (ratio of 2 and 3).</li> </ul>
Irrational numbers, ℍ	Irrational numbers are real numbers that cannot be expressed as a ratio of integers. The decimal form of an irrational number is nonterminating and nonrepeating. Examples: $\pi$ and $\sqrt{2}$

TIP Notice that the first

five letters of the word *rational* spell *ratio*. This will help you remember that a rational number is a *ratio* of integers.