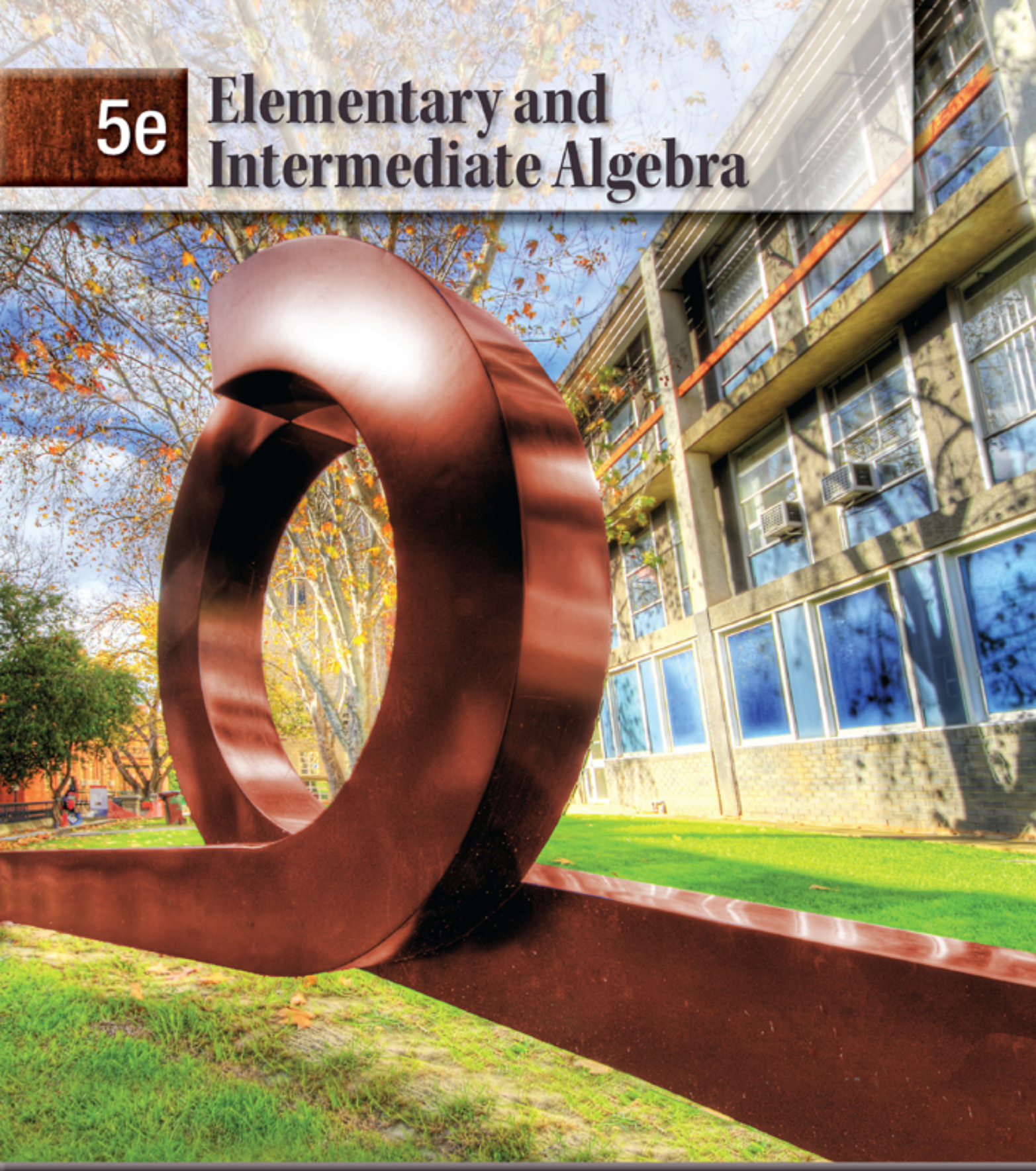
5e Elementary and Intermediate Algebra



ALAN S. TUSSY ■ R. DAVID GUSTAFSON

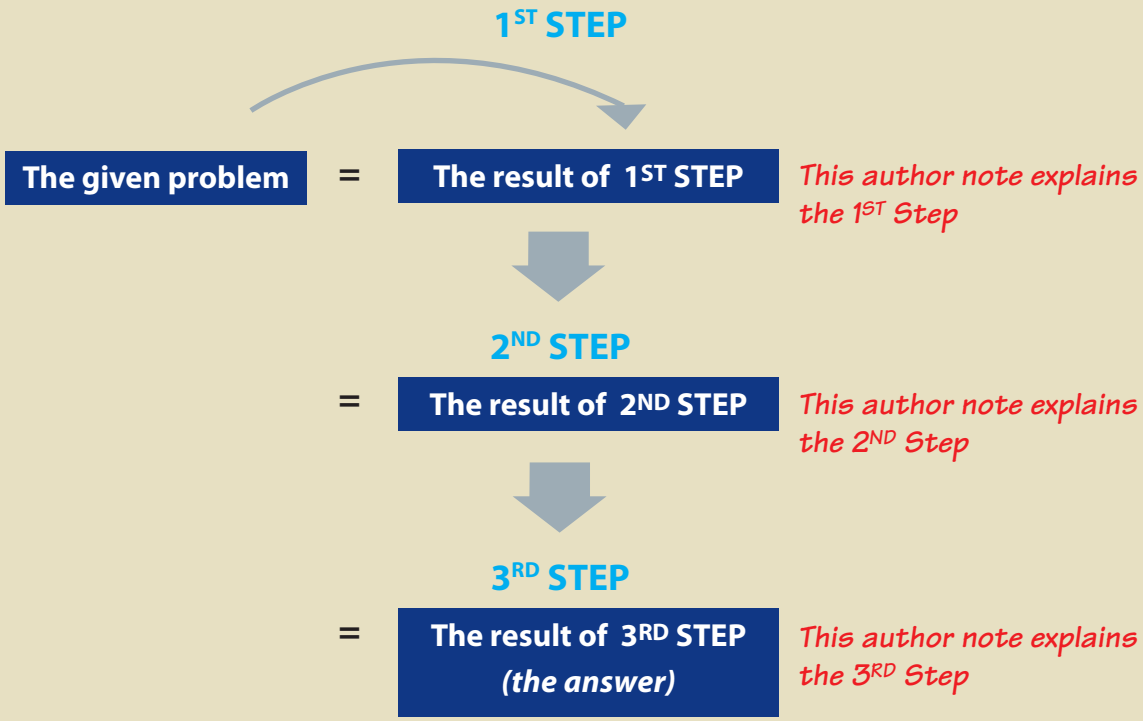
Experience the benefits of each worked example by understanding all of its features.

EXAMPLE 1 Here, we state the given problem.

Strategy Then, we explain what will be done to solve the problem.

Why Next, we explain why it will be done this way.

Solution The steps that follow show how the problem is solved by using the given strategy.



Self Check 1 A similar problem

Now Try ▶ Problem 29

After reading the example, try the Self Check problem to test your understanding. The answer is given in the *Answers to Selected Exercises* found in the back of the Student Edition text on page A-9.

After you work the Self Check, you are ready to try a similar problem in the *Guided Practice* section of the *Study Set*.

Before you begin, review your basic study skills.

Study Skills Workshop ▶ Making Homework a Priority

Attending class and taking notes are important, but they are not enough. The only way that you are really going to learn algebra is by doing your homework.

WHEN TO DO YOUR HOMEWORK: Homework should be started on the day it is assigned, when the material is fresh in your mind. It's best to break your homework sessions into 30-minute periods, allowing for short breaks in between.

HOW TO BEGIN YOUR HOMEWORK: Review your notes and the examples in your text before starting your homework assignment.

GETTING HELP WITH YOUR HOMEWORK: It's normal to have some questions when doing homework. Talk to a tutor, a classmate, or your instructor to get those questions answered.

Now Try This ▶

1. Write a one-page paper that describes *when, where,* and *how* you go about completing your algebra homework assignments.
2. For each problem on your next homework assignment, find an example in this book that is similar. Write the example number next to the problem.
3. Make a list of questions that you have while doing your next assignment. Then decide whom you are going to ask to get those questions answered.

To get the most out of the ***Study Skills Workshops*** that begin each chapter, you may choose to review them in the early weeks of your course. Each one includes action items, in addition to simple suggestions that can put you on a clear path to success. Below, we have included a table of contents to aid you in locating these:

CHAPTER 1 **Committing to the Course, p. 2**
Get started on the right foot by making time for your course, knowing what is expected by your instructor, building a support system.

CHAPTER 2 **Preparing to Learn, p. 102**
Get ready to learn by discovering your learning style, getting the most out of your textbook and any accompanying media or supplements, and taking good notes.

CHAPTER 3 **Successful Test Taking, p. 186**
Improve your chances for success by preparing for the test, using test-taking strategies, and evaluating your performance once your test has been graded.

CHAPTER 4 **Making Homework a Priority, p. 284**
Commit to completing your homework by starting on the day it is assigned, reviewing examples and notes before getting started, and knowing where to go for help if you have questions.

CHAPTER 5 **Attending Class Regularly, p. 384**
Recognize the value of class attendance and arrive on time. If you must miss a class, find out what you missed and be sure to study this material.

CHAPTER 6 **Reading the Textbook, p. 432**
Use your textbook strategically by skimming for an overview before going to class and reviewing the material after class by reading and making notes to deepen your understanding.

CHAPTER 7 **Study Groups, p. 512**
Form study groups early on in the course to share ideas and notes.

CHAPTER 8 **Maintaining a Positive Attitude, p. 600**
Strive to maintain a positive mental outlook for the entire term.

CHAPTER 9 **Don't Just Memorize, p. 728**
Memorization only provides a superficial grasp of the concepts, so strive to understand "why" and "when."

CHAPTER 10 **Organizing Your Notebook, p. 826**
Organize your notebook by chapter. Then, organize the papers within each section.

CHAPTER 11 **Participating in Class, p. 900**
To get the most out of class, ask questions, answer questions, and interact with classmates.

CHAPTER 12 **Preparing for a Final Exam, p. 1002**
Gear up for the final exam by getting organized, talking with your instructor, and managing your time.

CHAPTER 13 **Preparing for Your Next Math Course, p. 1076**
Take time to reflect on the study habits that have worked for you over the course and what you would like to do differently next time.

CHAPTER 14 **Exploring Careers, p. 1122**
Seek the advice of a career counselor and visit your campus career center. Then, develop your long-term plan to meet your career goals.

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Elementary and Intermediate Algebra

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Elementary and Intermediate Algebra

Alan S. Tussy
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In memory of my mother, Jeanene, and my dad, Bill.

—AST

To my wife, Carol,

with love and appreciation.

—RDG

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Alan Tussy teaches all levels of developmental mathematics at Citrus College in Glendora, California. He has written nine math books—a paperback series and a hard-cover series. A meticulous, creative, and visionary teacher who maintains a keen focus on his students' greatest challenges, Alan Tussy is an extraordinary author, dedicated to his students' success. Alan received his Bachelor of Science degree in Mathematics from the University of Redlands and his Master of Science degree in Applied Mathematics from California State University, Los Angeles. He has taught up and down the curriculum from prealgebra to differential equations. He is currently focusing on the developmental math courses. Professor Tussy is a member of the American Mathematical Association of Two-Year Colleges.

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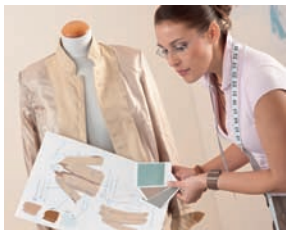
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PREFACE

We are excited to present the Fifth Edition of *Elementary and Intermediate Algebra.* We believe the revision process has produced an even stronger instructional experience for both students and teachers. First, we have fine-tuned several of the popular features of our series, including the *Strategy* and *Why* example structure, the problem-solving strategy, and the online homework.

Second, we have introduced some new features to further promote student understanding and success. The new *Look Alikes* problems in the *Study Sets* will help students improve their problem recognition. The *Are You Ready?* exercises that begin each section give students the opportunity to review necessary prerequisite skills before they are asked to apply them in the study of new topics. Furthermore, the additional *Campus to Careers* problems inserted in the *Study Sets* expand on the real-life applications of the chapter material.

We want to thank all of you throughout the country who have provided suggestions and input about the previous edition. Your insight has proven invaluable. Throughout this process, our fundamental belief has remained the same: Algebra is a language in its own right. And, as always, the prime objective of this textbook is to teach students how to read, write, speak, and think using the language of algebra.

New to the Fifth Edition

Sections That Begin with Review: *Are You Ready?*

Each section begins with a set of *Are You Ready?* problems. These problems review crucial prerequisite skills that students need to have mastered in order to be successful with the new topics of that section.

ARE YOU READY?

The following problems review some basic skills that are needed to find the slope of a line.

1. Evaluate: $\frac{4-1}{8-3}$

2. Evaluate: $\frac{-10-1}{-4-(-4)}$

3. Multiply: $-\frac{7}{9}\cdot\frac{9}{7}$

4. Simplify: $\frac{15}{18}$

Study Sets with More Problem-Recognition Practice: *Look Alikes*

After a poorer than expected performance on a test, students often tell their instructors, "I could do the homework each night, but when it comes to the test, I get confused." The new *Look Alikes* feature builds students' problem-recognition skills. It requires students to distinguish between similar looking problem types and then to select the correct strategy to solve the problem. Encountering such situations in the homework assignments will better prepare students for quizzes and tests.

Look Alikes . . .

Perform the indicated operations to simplify each expression, if possible.

105. **a.** $(x-2)+(x^2+2x+4)$ **b.** $(x-2)(x^2+2x+4)$

106. **a.** $(a+3)+(a^2-3a+9)$ **b.** $(a+3)(a^2-3a+9)$

107. **a.** $(6x^2z^5)-(-3xz^3)$ **b.** $(6x^2z^5)(-3xz^3)$

108. **a.** $(-5r^4t^2)-(2r^2t)$ **b.** $(-5r^4t^2)(2r^2t)$

109. **a.** $(2x^2-x)-(3x^2-3x)$ **b.** $(2x^2-x)(3x^2-3x)$

110. **a.** $(4.9a-b)-(2a+b)$ **b.** $(4.9a-b)(2a+b)$

And Even More Problem-Recognition Practice: *Try It Yourself*

Designed to promote problem recognition, instructors and reviewers requested more *Try It Yourself* problems for the Fifth Edition. These problem types are thoroughly mixed, giving students an opportunity to practice decision making and strategy selection as they would when taking a test or quiz. With more than 80% more problems added, students will have even more opportunities to practice this essential skill.

TRY IT YOURSELF

Graph each equation. Solve for y first, when necessary.

53. $y = x$
54. $y = 4x$
55. $y = -x - 1$
56. $y = -x + 2$
57. $3y = 12x + 15$
58. $5y = 20x - 30$
59. $y = \frac{3}{8}x - 6$
60. $y = -\frac{3}{2}x + 2$
61. $y = 1.5x - 4$
62. $y = 0.5x + 3$
63. $8x + 4y = 16$
64. $14x + 7y = 28$
65. $y = -\frac{1}{2}x$
66. $y = \frac{3}{4}x$
67. $y = \frac{5}{6}x - 5$
68. $y = \frac{2}{3}x - 2$
69. $-6y = 30x + 12$
70. $-3y = 9x - 15$

Comprehensive Test Preparation: *Chapter Tests*

Instructors often assign an end-of-chapter test for students to use as a means to study for a classroom exam. However, after taking the exam, students often remark that the classroom exam included problem types that weren't in the *Chapter Test*. To address this issue, we have made sure that each *Chapter Test* is a comprehensive collection of problems that covers *all* of the topics discussed in the chapter. As a result, the *Chapter Tests* are lengthy. If students have time to complete a *Chapter Test,* that would be optimal. If, because of time constraints, they are unable to do so, the instructor can assign an appropriate subset of problems that reflects the types of problems that students can see on the exam. This should alleviate the discrepancy between what students practice and what they will see on the test.

2 CHAPTER TEST

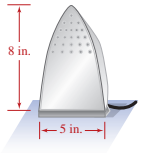
1. Fill in the blanks.
   a. To _____ an equation means to find all of the values of the variable that make the equation true.
   b. _____ means parts per one hundred.
   c. The distance around a circle is called its _____.
   d. An _____ is a statement that contains one of the symbols $>, \geq, <,$ or $\leq$.
   e. The _____ property of _____ says that multiplying both sides of an equation by the same nonzero number does not change its solution.
2. Use a check to determine if 3 is a solution of $5y + 2 = 12$.

Solve each equation.

3. $3h + 2 = 8$
4. $-22 = -x$
5. $\frac{4}{5}t = -4$
6. $\frac{11b - 11}{5} = \frac{3b - 2}{2}$
7. $0.8(x - 1{,}000) + 1.3 = 2.9 + 0.2x$
8. $2(y - 7) - 3y = -(y - 3) - 17$
9. $\frac{m}{2} - \frac{1}{3} = \frac{1}{4} + \frac{m}{6}$
10. $\frac{3}{4}(6n - 2) = 246$
11. $5x = 0$

Solve for the specified variable.

23. $V = \pi r^2 h$ for h
24. $A = P + Prt$ for r
25. $A = \frac{a + b + c + d}{4}$ for c
26. $2x - 3y = 9$ for y
27. **Irons.** Estimate the area of the soleplate of the iron.



28. **Television.** In a typical 30-minute block of time on TV, the number of programming minutes are 2 less than three times the number of minutes of commercials. How many minutes of programming and how many minutes of commercials are there?

Additional Relevant, Motivating Applications in the *Examples* and *Study Sets*

We have included many new applied examples and problems that involve relevant topics such as our environment and sustainability issues, energy savings, technology and social media, and recycling. For a complete list of topics, see the *Index of Applications* following the *Preface.* To see a sampling of new topics added to each chapter, see *Content Changes by Chapter* in this *Preface.*

EXAMPLE 6 **Water Management.** Lake Mead, on the Nevada-Arizona border, is the largest reservoir in the United States. It is formed by Hoover Dam across the Colorado River. In 2000, the water level in Lake Mead was 89 feet above drought level. By 2010, the water level was 27 feet below drought level. Find the change in the water level over that time span. (Source: Bureau of Reclamation)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Strategy We can represent a water level above drought level using a positive number and a water level below drought level using a negative number. To find the change in the water level, we will subtract.

Why In general, *to find the change in a quantity, we subtract the earlier value from the later value.*

Solution $-27 - 89 = -27 + (-89)$ The earlier water level in 2000 (89 ft) is subtracted

$= -11$(6

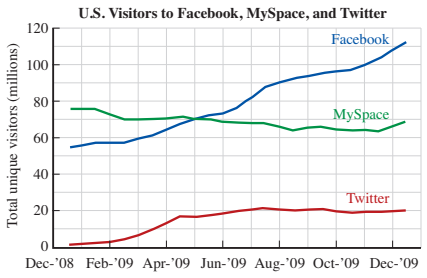
The negative result indica

Self Check 6 Find th
normal

Now Try Problem

APPLICATIONS

73. **Social Networks.** Refer to the graph below. In what month did Facebook and MySpace have the same number of unique visitors? Estimate the number.



Source: Comscore Media Metrix

A More Precise Problem-Solving Strategy

In an effort to better describe the problem-solving strategy used in this book, we have inserted a new second step in what was formerly a five-step process. This additional step (*Assign a variable to represent an unknown value in the problem.*) better delineates the thought process students should use as they solve application problems. The six steps of the problem-solving strategy are now: *Analyze the problem*, *Assign a variable*, *Form an equation*, *Solve the equation*, *State the conclusion*, and *Check the result.*

EXAMPLE 11

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Grades. A student has scores of 72%, 74%, and 78% on three exams. What percent score does he need on the last exam to earn a grade of no less than B (80%)?

Analyze We know three scores. We are to find what the student must score on the last exam to earn a grade of B or higher.

Assign Let x = the score on the fourth (and last) exam.

Form To find the average grade, we add the four scores and divide by 4. To earn a grade of *no less than* B, the student's average must be *greater than or equal to* 80%.

The average of the four grades must be no less than 80.

$$\frac{72 + 74 + 78 + x}{4} \geq 80$$

The Language of Algebra

Some phrases that suggest an inequality are:

surpass: $>$ at least: $\geq$
not exceed: $\leq$ at most: $\leq$
is no less than: $\geq$
is no greater than: $\leq$
between: $\square < \square < \square$

Solve

$$\frac{224 + x}{4} \geq 80$$ Combine like terms in the numerator: $72 + 74 + 78 = 224$.

$$4\left(\frac{224 + x}{4}\right) \geq 4(80)$$ To clear the inequality of the fraction, multiply both sides by 4.

$$224 + x \geq 320$$ Simplify each side.

$$x \geq 96$$ To isolate x, undo the addition of 224 by subtracting 224 from both sides.

State To earn a B, the student must score 96% or better on the last exam.

Check Pick several exam scores that are 96% or better and verify that the student's average will be 80% or greater. For example, a score of 96% gives the student an average that is exactly 80%.

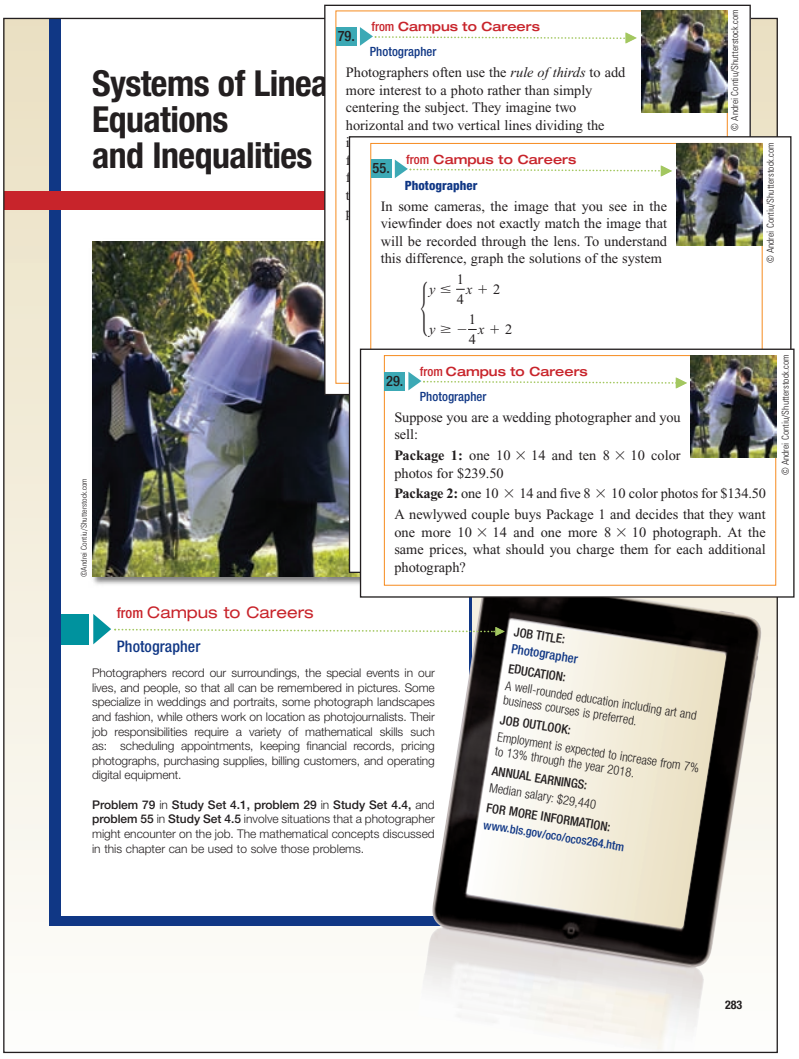
$$\frac{72 + 74 + 78 + 96}{4} = \frac{320}{4} = 80$$

Self Check 11 **Grades.** A student has scores of 78%, 82%, and 76% on three exams. What percent score does he need on the last test to earn a grade of no less than a B (80%)?

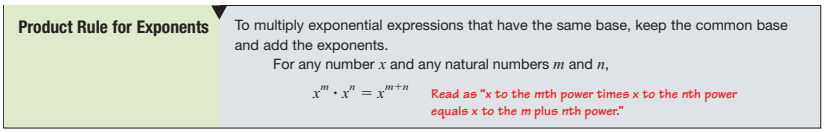
Now Try Problem 103

More Emphasis on "When Will I Use This?"

Each chapter now has three *Campus to Careers* problems that explore the mathematical connections to careers that are presented at the beginning of each chapter.



Reading the Language of Algebra



Students often have difficulty reading the mathematical notation of algebra and, as a consequence, their understanding suffers. To provide assistance in this area, we have inserted notes that explain how to read newly introduced notation. Students will appreciate the ever-present "Read as ..." statements that follow algebraic symbolism that they encounter for the first time.

Trusted Features

- **Examples That Show You How . . . and WHY:** Why? That question is often asked by students as they watch their instructors solve problems in class and as they are working on problems at home. It's not enough to know how a problem is solved. Students gain a deeper understanding of the algebraic concepts if they know why a particular approach was taken. This instructional truth was the motivation for adding a Strategy and Why explanation to each worked example.
- **Examples That Offer Immediate Feedback:** Each worked example includes a Self Check. You can complete these on your own after reading the worked example or your instructor may choose to use them as classroom lecture examples. The Self Check answers can be found in the *Answers to Selected Exercises* in the back of the text.
- **Examples That Ask You to Work Independently:** Each worked example ends with a Now Try problem. These are the final step in the learning process. Each one is linked to a similar problem found within the *Guided Practice* sections of the *Study Sets,* offering you a smooth transition into the homework.
- **Study Sets** found in each section offer a multifaceted approach to practicing and reinforcing the concepts taught in each section. They are designed for students to build their knowledge of the section concepts methodically, from basic recall to increasingly complex problem solving, through reading, writing, and thinking mathematically.

  Vocabulary—Each *Study Set* begins with the important *Vocabulary* discussed in that section. The fill-in-the-blank vocabulary problems emphasize the main concepts taught in the chapter and provide the foundation for learning and communicating the language of algebra.

  Concepts—In *Concepts,* students are asked about the specific subskills and procedures necessary to successfully complete the *Guided Practice* and *Try It Yourself* problems that follow.

  Notation—*Notation* problems review the new symbols introduced in a section. Often, students are asked to fill in steps of a sample solution. This strengthens their ability to read and write mathematics and prepares them for the *Guided Practice* problems by modeling solution formats.

  Guided Practice—The *Guided Practice* section of each *Study Set* consistently provides 1-to-1 linking for each problem type to a single worked example or objective (*i.e.*, See Example 1, See Example 2, See Example 3, and so on). Students will appreciate this 1-to-1 linking as opposed to the all-encompassing linking statements such as See Examples 2–8 or See Example 7–11 that are found in some textbooks.

  Try It Yourself—To promote problem recognition, the *Try It Yourself* problems are thoroughly mixed and are *not* linked to worked examples, giving students an opportunity to practice decision making and strategy selection as they would when taking a test or quiz.

  Applications—The *Applications* provide students the opportunity to apply their newly acquired algebraic skills to relevant and interesting real-life situations.

  Writing—The *Writing* problems help students build mathematical communication skills.

Review—The *Review* problems consist of randomly selected problems from previous chapters. These problems are designed to keep students' successfully mastered skills up-to-date before they move on to the next section.

Challenge Problems—The *Challenge Problems* provide students with an opportunity to stretch themselves and develop their skills beyond the basics. Instructors often find these to be useful as extra-credit problems.

- **Detailed Author Notes** that guide students along in a step-by-step process appear in the solutions to every worked example.
- **The Language of Algebra** boxes draw connections between mathematical terms and everyday references to reinforce the language of algebra thread that runs throughout the text.
- **The Notation, Success Tips, Caution,** and **Calculators** boxes offer helpful tips to reinforce correct mathematical notation, improve students' problem-solving abilities, warn students of potential pitfalls and increase clarity, and offer tips on using scientific calculators.
- **Chapter Tests,** at the end of every chapter, can be used as preparation for the class exam.
- **Cumulative Reviews** follow the end-of-chapter material and keep students' skills current before moving on to the next chapter. Each problem is linked to the associated section from which the problem came for ease of reference. The final *Cumulative Review* often is used by instructors as a final exam review.
- **Using Your Calculator** is an optional feature that is designed for instructors who want to use calculators as part of the instruction in this course. This feature introduces keystrokes and shows how scientific and graphing calculators can be used to solve problems. In the *Study Sets,* icons are used to denote problems that may be solved using a calculator.

Content Changes by Chapter

Based on feedback from colleagues and users of the Fourth Edition, the following changes have been made in an effort to further streamline and update the text.

Chapter 1

- New example and exercise applications include topics such as snowboarding, Lake Mead water levels, melting glaciers, calories burned doing housework, lost luggage, iPhone signal strength, U.S. Federal Budget Deficit/Surplus, and average wait time in airport security lines.
- New instructional features include a screened color 1 that is used when explaining how to build and simplify fractions, additional notes explaining how the notation is read, a worked example demonstrating uses of the commutative and associative properties, a more comprehensive *Chapter Test,* additional cautions, and an upgraded *Group Project.*

Chapter 2

- New example and exercise applications include topics such as Twitter, how tire pressure affects gas mileage, rainforest deforestation, Craigslist ads, *Harry Potter* box office revenue, calculating horsepower, iPhone apps, water usage, consignment shops, signing bonuses, and target heart rates.
- New instructional features include a comparison of linear and nonlinear equations, a new worked example of solving formulas for a specified variable, a new step added to the problem-solving strategy (*Assign a variable.*), additional cautions, additional explanation of consecutive integers, a worked example showing how to clear an inequality of fractions to solve it, and a more comprehensive *Chapter Test.*

Chapter 3

- New example and exercise applications include topics such as the Hollywood sign, René Descartes, endangered species, the U.S. Space Program, Honda Insight gas mileage, renewable energy, dental-assistant programs, firefighting, printing presses, calculating the cost to use an iPad, online games, U.S. credit card debt, the cost of raising a family, managing dental appointment times, and the amount of carbon dioxide in the Earth's atmosphere.
- New instructional features include a comparison of linear and nonlinear equations, tips for constructing a table of solutions for equations of the form $Ax + By = 0$, a comparison of one- and two-dimensional graphs, lines with slopes 1 and -1, additional cautions, a summary table of the forms of linear equations in two variables, and a more comprehensive *Chapter Test.*

Chapter 4

- New example and exercise applications include topics such as social networking, using the *rule of thirds* when taking photographs, the cost of changing CFL light bulbs, the number of women awarded Bachelor's degrees, sources of electricity, newspaper readership, greenhouse gas emissions, and lung cancer statistics.
- New instructional features include additional emphasis on what to write when both variables drop out when using the substitution method, a new step added to the problem-solving strategy (*Assign variables to the unknowns.*), additional cautions, and a comparison of one-variable and two-variable approaches to solving application problems.

Chapter 5

- New example and exercise applications include topics such as threshold hearing, supercomputers, replacing a fan belt, and diabetes diagnoses.
- New instructional features include additional notes explaining how exponential notation is read, additional cautions, a verification that the definitions of zero and negative exponents are consistent with students' previous experience with exponents, a more visible explanation showing how to multiply and divide numbers written in scientific notation, a comparison of polynomials and expressions that are not polynomials, an additional example of polynomial subtraction (vertical form), and more detailed author notes explaining polynomial long division.

Chapter 6

- New example and exercise applications include topics such as making crayons, staining a front door, Grammy nominations, antique shows, and rate of change of Wikipedia entries.
- New instructional features include a worked example in which the terms of a polynomial are rearranged to facilitate factoring by grouping, additional factoring tips, additional insight into factoring using the key number method, more information about how to recognize perfect-square trinomials, alternate factoring approaches, additional *Language of Algebra* boxes, and a more extensive list of types of quadratic equations.

Chapter 7

- New example and exercise applications include topics such as preparing an operating room, number of Tweets per ten seconds, building design, computer hard drives, and exercise equipment depreciation.
- New instructional features include a screened color 1 that is used when explaining how to build and simplify fractions, a worked example in which the common factor $x + 1$ in the numerator and $1 + x$ in the denominator are removed, and increased use of the term *rational expression* in place of the word *fraction.*

Chapter 8

- New example and exercise applications include topics such as websites, packaging, breathing capacity, airline seating, health care, earthquakes, and currency exchange.
- New instructional features include several new *Success Tips,* a more detailed discussion of identities and contradictions, increased emphasis on polynomial functions and their graphs, a more detailed explanation of finding the domain of a function, a more in-depth discussion of rational functions and their graphs, new examples and *Study Set* problems about addition, subtraction, multiplication, and division of functions, a screened color 1 is used when explaining how to build and simplify fractions, and a more comprehensive *Chapter Test.*

Chapter 9

- New example and exercise applications include topics such as matting art and beach pollution.
- New instructional features include some new *Language of Algebra* and *Caution* features, a more in-depth discussion of radical functions and their graphs, additional notes explaining how the notation is read, a screened color 1 is used when explaining how to rationalize expressions, additional worked examples and *Study Set* problems about addition, subtraction, and multiplication of radical expressions, a new worked example and *Study Set* problems about solving equations containing fractional exponents, a more detailed discussion of the complex number system, the midpoint formula has been moved from Section 8.7 to Section 9.6, and a more comprehensive *Chapter Test.*

Chapter 10

- New example and exercise applications include topics such as physics, shopping centers, women in law enforcement, crowd control, hospital emergency departments, comparing job offers, and oceanography.
- New instructional features include a new worked example and *Study Set* problems about quadratic functions, some new *Language of Algebra, Caution,* and *Success Tip* features, a new worked example and *Study Set* problems about quadratic equations with complex-number solutions, a revamped strategy for solving quadratic equations, and a more comprehensive *Chapter Test.*

Chapter 11

- New example and exercise applications include topics such as medication absorption, atmospheric carbon dioxide concentrations, book publishing, U.S. poverty rates, stocking lakes, the Richter scale, social services case loads, buying advertising time, bed bugs, cross-country skiing, weight training progress, gross domestic product of U.S. states, and human growth hormone.
- New instructional features include additional notes explaining how the notation is read, a new worked example and *Study Set* problems about evaluating sum, difference, product, quotient, and composition functions, comparison and contrast of other types of functions to exponential functions, a more detailed discussion of exponential growth and decay models and their graphs, new visuals relating exponential and logarithmic forms, a new visual explaining logarithmic function notation, a new worked example and *Study Set* problems about logarithmic growth, the former Fourth Edition Sections 11.4 and 11.6 were combined to create a new *Section 11.5: Base-e Exponential and Logarithmic Functions,* updated calculator keystrokes instructions, a revamped strategy for solving quadratic equations, more author notes and steps shown in the solutions for worked examples solving logarithmic equations, and a more comprehensive *Chapter Test.*

Chapter 12

- New example and exercise applications include topics such as footwear imports, area codes, investing, interior design, fashion design, physical therapy, hair color treatments,

production planning, manufacturing, nutrition, NBA centers, television vs. internet video viewing, student loans, gourmet fruit, weight training, and railroad safety.

- New instructional features include moving the application problems to the end of the chapter in Sections 12.4 and 12.5 so that any of the methods (substitution, elimination, matrices, Cramer's rule) could be used to solve the system of equations, updated graphing calculator keystrokes instructions, a more precise definition of a set of dependent equations, reduced row-echelon form and Gauss-Jordan elimination, more *Notation* and *Language of Algebra* features, additional use of tables for problem solving, and a more comprehensive *Chapter Test.*

Chapter 13

- New example and exercise applications include topics such as civil engineering, landscaping, nuclear power, and advertising.
- New instructional features include several new *Success Tips* about determining *h* and *k,* a more in-depth discussion of the role of the center when graphing conics, a discussion of the curvature of the branches of a hyperbola, and a more comprehensive *Chapter Test.*

Chapter 14

- New example and exercise applications include topics such as union membership, manufacturing costs, and flight times.
- New instructional features include several new *Notation* and *Success Tip* features explaining notation, several new *Language of Algebra* features, a discussion of the curvature of the branches of a hyperbola, and a more comprehensive *Chapter Test.*

Student Resources

Print Ancillaries

Complete Course Notebook (1-133-36448-9)
Ann Ostberg
NEW! The *Complete Course Notebook* is your blueprint for success in your algebra course and in all your future studies! This notebook organizes and guides you through your course, offering step-by-step practice related to each section of your textbook. Each chapter contains a chapter readiness assessment, fill-in-the-blank course notes, structured note-taking guides, questions for reflection, activities, and end-of-chapter test prep. The notebook also contains general tip sheets on note-taking, studying, assessing your test scores, and much more.

Student Workbook (1-111-98783-1)
Maria H. Andersen, *Muskegon Community College*
Get a head-start. The *Student Workbook* contains assessments, activities, and worksheets for classroom discussions, in-class activities, and group work.

Student Solutions Manual (1-111-57847-8)
Alexander Lee, *Hinds Community College* and Kristy Hill, *Hinds Community College*
The *Student Solutions Manual* provides worked-out solutions to the odd-numbered problems in the text.

Enhanced WebAssign: Start Smart Guide for Students (0-495-38479-8)
If your instructor has chosen to package *Enhanced WebAssign* with your text, this manual will help you get up and running quickly with the *Enhanced WebAssign* system so you can study smarter and improve your performance in class.

Electronic Ancillaries

Enhanced WebAssign (0-538-73810-3)
Get instant feedback on your homework assignments with *Enhanced WebAssign* (assigned by your instructor). This online homework system is easy to use and includes a multimedia eBook, video examples, and problem-specific tutorials.

Website www.cengagebrain.com or www.cengage.com/math/tussy
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The more you study, the better the results. Make the most of your study time by accessing everything you need to succeed in one place: read your textbook, take notes, review flashcards, watch videos, and take practice quizzes—online with *CourseMate.*

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INDEX OF APPLICATIONS

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An Introduction to Algebra

1

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1.2 Fractions
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1.8 Algebraic Expressions
1.9 Simplifying Algebraic Expressions Using Properties of Real Numbers

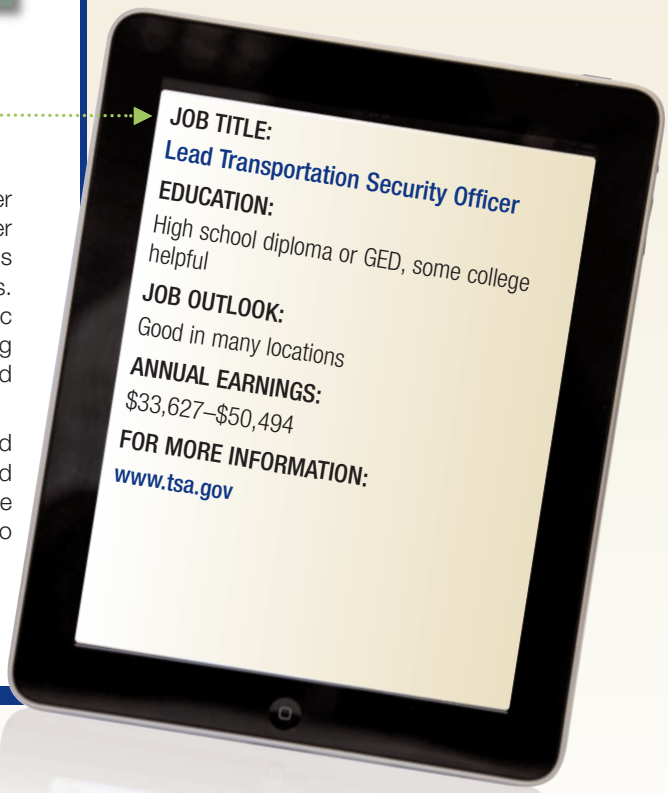
CHAPTER SUMMARY AND REVIEW
CHAPTER TEST
GROUP PROJECT

from Campus to Careers

Lead Transportation Security Officer

Since 9/11, Homeland Security is one of the fastest-growing career choices in the United States. A lead transportation security officer works in an airport where he or she searches passengers, screens baggage, reviews tickets, and determines staffing requirements. The job description calls for the ability to perform arithmetic computations correctly and solve practical problems by choosing from a variety of mathematical techniques such as formulas and percentages.

Problem 113 in **Study Set 1.2, Problem 99** in **Study Set 1.5,** and **Problem 117** in **Study Set 1.7** involve situations that a lead transportation security officer might encounter on the job. The mathematical concepts discussed in this chapter can be used to solve those problems.



Study Skills Workshop ▶ Committing to the Course

Starting a new course is exciting, but it might also make you a bit nervous. In order to be successful in your algebra class, you need a plan.

MAKE TIME FOR THE COURSE: As a general guideline, 2 hours of independent study time is recommended for every hour in the classroom.

KNOW WHAT IS EXPECTED: Read your instructor's syllabus thoroughly. It lists class policies about attendance, homework, tests, calculators, grading, and so on.

BUILD A SUPPORT SYSTEM: Know where to go for help. Take advantage of your instructor's office hours, your school's tutorial services, the resources that accompany this textbook, and the assistance that you can get from classmates.

Now Try This ▶

Each of the forms referred to below can be found online at: www.cengage.com/math/tussy.

1. To help organize your schedule, fill out the *Weekly Planner Form.*
2. Review the class policies by completing the *Course Information Sheet.*
3. Use the *Support System Worksheet* to build your course support system.

SECTION 1.1

OBJECTIVES

1. Read tables and graphs.
2. Use the basic vocabulary and notation of algebra.
3. Identify expressions and equations.
4. Use equations to construct tables of data.

Introducing the Language of Algebra

ARE YOU READY?

The following problems review some basic arithmetic skills that are needed in this section. Answers to the Are You Ready? *problems are located in Appendix 3 at the back of the book.*

1. Add: $125 + 85$
2. Subtract: $2{,}400 - 650$
3. Multiply: $78 \cdot 14$
4. Divide: $243 \div 27$

Algebra is the result of contributions from many cultures over thousands of years. The word *algebra* comes from the title of the book *Ihm Al-jabr wa'l muqābalah,* written by an Arabian mathematician around A.D. 800. We can think of algebra as a language with its own vocabulary and notation. In this section, we begin to explore the language of algebra by introducing some of its basic components.

1 Read Tables and Graphs.

In algebra, we often use **tables** to show relationships between quantities. For example, the table below lists the number of calories a 160-pound adult burns during 10, 20, 30, and 40 minutes of snowboarding. For a workout of, say, 30 minutes, we locate 30 in the left column and then scan across the table to see that 300 calories are burned.

©Ipatov/Shutterstock.com

Minutes snowboarding	Calories burned
10	100
20	200
30	300
40	400

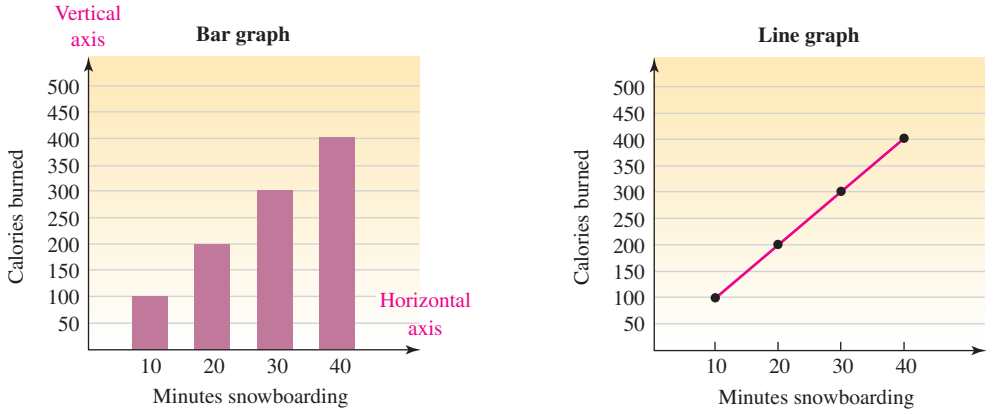
The information in the table also can be presented in a **bar graph,** as shown on the next page, on the left. The **horizontal axis** of the graph is labeled "Minutes snowboarding," and it

The Language of Algebra

Horizontal is a form of the word *horizon.* Think of the sun setting over the *horizon.* **Vertical** means in an upright position. Professional basketball player LeBron James' *vertical* leap measures more than 40 inches.

is scaled in units of 10 minutes. The **vertical axis,** labeled "Calories burned," is scaled in units of 50 calories. The height of a bar indicates the number of calories burned. For example, the bar over 40 minutes extends upward to 400. This means 400 calories are burned during a 40-minute snowboarding workout.

Another way to present the snowboarding information is with a **line graph.** Instead of using a bar to represent the number of calories burned, we use a dot drawn at the correct height. After drawing the data points for workouts of 10, 20, 30, and 40 minutes, we connect them with line segments to create the graph shown below, on the right.



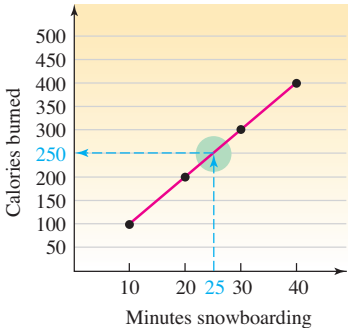
EXAMPLE 1 **Fitness.** Use the line graph above to find the number of calories burned during a 25-minute snowboarding workout.

Strategy We will start at 25 on the horizontal axis of the graph. Then we will scan up to the red line, and over, to read the number of calories burned on the vertical axis.

Why We start on the horizontal axis because that scale gives the number of minutes of snowboarding. We scan up and over to the vertical axis because that scale gives the number of calories burned.

Solution

We locate 25 minutes (between 20 and 30 minutes) on the horizontal axis and draw a dashed line upward to intersect the red line. From the point of intersection, we then draw a dashed line to the left that points to the vertical axis at 250. This means that a 25-minute snowboarding workout burns 250 calories.



Success Tip

Answers to the Self Check problems are given in Appendix 3, at the back of the book.

Self Check 1 **Fitness.** Use the graph to find the number of calories burned during a 35-minute snowboarding workout.

Now Try Problem 29

2 Use the Basic Vocabulary and Notation of Algebra.

From the table and graphs, we see that there is a relationship between the number of calories burned and the number of minutes snowboarding. Using words, we can express this relationship as a **verbal model:**

"The number of calories burned is ten times the number of minutes snowboarding."

Since the word **product** indicates the result of a multiplication, we can also write:

"The number of calories burned is the *product* of ten and the number of minutes snowboarding."

The Language of Algebra

The collection of symbols and write-up forms used in this course is called the **notation** of algebra.

To indicate other arithmetic operations, we will use the following words.

- A **sum** is the result of an addition: The sum of 5 and 6 is 11.
- A **difference** is the result of a subtraction: The difference of 3 and 2 is 1.
- A **quotient** is the result of a division: The quotient of 6 and 3 is 2.

Many symbols used in arithmetic are also used in algebra. For example, a $+$ symbol is used to indicate addition, a $-$ symbol is used to indicate subtraction, and an $=$ symbol means *is equal to.*

Since the letter x is often used in algebra and could be confused with the multiplication symbol $\times$, we usually write multiplication using a **raised dot** or **parentheses.**

Symbols for Multiplication

$\times$	Times symbol	$6 \times 4 = 24$
$\cdot$	Raised dot	$6 \cdot 4 = 24$
$(\ )$	Parentheses	$(6)4 = 24$ or $6(4) = 24$ or $(6)(4) = 24$

In algebra, the symbol most often used to indicate division is the **fraction bar.**

Symbols for Division

$\div$	Division symbol	$24 \div 4 = 6$
$\overline{)}$	Long division	$4\overline{)24}$ $\quad 6$
—	Fraction bar	$\frac{24}{4} = 6$

EXAMPLE 2 Write each statement in words, using one of the words *sum, product, difference,* or *quotient:*

a. $\frac{22}{11} = 2$ **b.** $22 + 11 = 33$

Strategy We will examine each statement to determine whether addition, subtraction, multiplication, or division is being performed.

Why The word that we should use (*sum, product, difference,* or *quotient*) depends on the arithmetic operation that we have to describe.

Solution

a. Since the fraction bar indicates division, we have: The quotient of 22 and 11 equals 2.

b. The $+$ symbol indicates addition: The sum of 22 and 11 equals 33.

Self Check 2 Write the following statement in words: $22 \cdot 11 = 242$

Now Try Problems 33 and 35

3 Identify Expressions and Equations.

The Language of Algebra

Since the number of minutes snowboarding can *vary,* or change, it is represented using a **variable.**

Another way to describe the relationship between calories burned and snowboarding time uses *variables.* **Variables** are letters that stand for numbers. If we let the letter m represent the number of minutes snowboarding, then the number of calories burned is ten times m, written $10m$. In this notation, the number 10 is an example of a **constant** because it does not change value.

When multiplying a variable by a number, or a variable by another variable, we can omit the symbol for multiplication. For example,

$10m$ means $10 \cdot m$ $\qquad$ xy means $x \cdot y$ $\qquad$ $8abc$ means $8 \cdot a \cdot b \cdot c$

We call $10m$, xy, and $8abc$ *algebraic expressions.*

Algebraic Expressions

Variables and/or numbers can be combined with the operations of addition, subtraction, multiplication, and division to create **algebraic expressions.**

The Language of Algebra

Algebraic expressions are often simply called **expressions.**

Here are some other examples of algebraic expressions.

$4a + 7$ This expression is a combination of the numbers 4 and 7, the variable a, and the operations of multiplication and addition.

$\frac{10 - y}{3}$ This expression is a combination of the numbers 10 and 3, the variable y, and the operations of subtraction and division.

$15mn(2m)$ This expression is a combination of the numbers 15 and 2, the variables m and n, and the operation of multiplication.

The Language of Algebra

The equal symbol $=$ can be represented by verbs such as:

is *are* *gives* *yields*

The symbol $\neq$ is read as *"is not equal to."*

In the snowboarding example, if we let the letter c stand for the number of calories burned, we can translate the verbal model to mathematical symbols.

The number of calories burned	is	ten	times	the number of minutes snowboarding.
c	$=$	10	$\cdot$	m

The statement $c = 10 \cdot m$, or more simply, $c = 10m$, is called an *equation.* An **equation** is a mathematical sentence that contains an $=$ symbol. The $=$ symbol indicates that the expressions on either side of it have the same value. Other examples of equations are

$$3 + 5 = 8 \qquad x + 5 = 20 \qquad 17 - 2r = 14 + 3r \qquad p = 100 - d$$

EXAMPLE 3

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Stormy Weather. One way to estimate your distance (in miles) from a lightning strike is to count the number of seconds between the flash of lightning and the sound of thunder and divide by five. Translate this verbal model into an equation.

Strategy We will represent the two unknown quantities using variables and we will use symbols to represent the words *is* and *divided by.*

Why To translate a verbal (word) model into an equation means to write it using mathematical symbols.

Solution

Let d = your distance (in miles) from the lightning strike and s = the number of seconds between the lightning and the thunder. Then we have:

Your distance (in miles) from the lightning strike	is	the number of seconds between the lightning and thunder	divided by	five.
d	$=$	s	$\div$	5

If we write the division using a fraction bar, then the verbal model translates to the equation $d = \frac{s}{5}$.

Success Tip

Throughout this course you will be working with *expressions* and *equations.* It is important to know the difference between them. An equation contains an $=$ symbol. An expression does not.

Self Check 3 Translate into an equation: The number of unsold tickets is the difference of 500 and the number of tickets that have been purchased.

Now Try Problems 41 and 45

In the snowboarding example, we have seen that a table, a graph, and an equation can be used to describe the relationship between calories burned and workout time. The equation $c = 10m$ has one major advantage over the other methods. It can be used to accurately determine the number of calories burned during a snowboarding workout of *any* length of time.

EXAMPLE 4 **Fitness.** Use the equation $c = 10m$ to find the number of calories burned during a 36-minute snowboarding workout.

Strategy In $c = 10m$, we will replace m with 36. Then we will multiply 36 by 10 to obtain the value of c.

Why The equation $c = 10m$ indicates that the number of calories burned is found by multiplying the number of minutes snowboarding by 10.

Solution

$c = 10m$ This is the describing equation.

$c = 10(36)$ Replace m, which stands for the number of minutes snowboarding, with 36. Use parentheses to show the multiplication. We also could write $10 \cdot 36$.

$c = 360$ Do the multiplication.

A snowboarding workout of 36 minutes will burn 360 calories.

Self Check 4 **Fitness.** Use the equation $c = 10m$ to find the number of calories burned during a 48-minute snowboarding workout.

Now Try Problem 53

4 Use Equations to Construct Tables of Data.

Equations such as $c = 10m$, which express a relationship between two or more variables, are called **formulas.** Some applications require the repeated use of a formula.

EXAMPLE 5 **Fitness.** Find the number of calories burned during snowboarding workouts of 18 minutes and 65 minutes. Present the results in a table.

Strategy We need to use the formula $c = 10m$ twice.

Why There are two different workouts: one that is 18 minutes long and another that is 65 minutes long.

Solution

Step 1: We construct a two-column table and enter the workout times in the first column, as shown below in red.

The Language of Algebra

To **substitute** means to put or use in place of another, as with a *substitute* teacher. Here, we *substitute* 18 and 65 for m.

$c = 10m$

m	c
18	180
65	650

Since m represents the number of minutes snowboarding, we use it as the heading of the first column.

Since c represents the number of calories burned, we use it as the heading of the second column.

Step 2: We substitute 18 and 65 for m in $c = 10m$ and find each corresponding value of c. The results are entered in the second column of the table, as shown above.

$c = 10m$ $\quad$ $c = 10m$

$c = 10(18)$ $\quad$ $c = 10(65)$

$c = 180$ $\quad$ $c = 650$

Success Tip

Answers to the odd-numbered problems in each Study Set can be found at the back of the book in Appendix 3, beginning on page A-9.

Self Check 5 **Fitness.** Find the number of calories burned during snowboarding workouts of 8 minutes and 75 minutes. Present the results in a table.

Now Try Problem 55

SECTION 1.1 STUDY SET

VOCABULARY

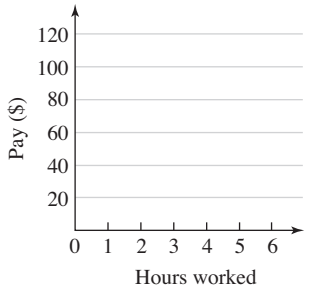
Fill in the blanks.

1. A _____ is the result of an addition. A _____ is the result of a subtraction. A _____ is the result of a multiplication. A _____ is the result of a division.
2. _____ are letters (or symbols) that stand for numbers.
3. A number, such as 8, is called a _____ because it does not change.
4. Variables and numbers can be combined with the operations of addition, subtraction, multiplication, and division to create algebraic _____.
5. An _____ is a mathematical sentence that contains an $=$ symbol. An algebraic _____ does not.
6. An equation such as $c = 10m$, which expresses a relationship between two or more variables, is called a _____.
7. The _____ axis of a graph extends left and right and the vertical axis extends up and down.
8. The word _____ comes from the title of a book written by an Arabian mathematician around A.D. 800.

CONCEPTS

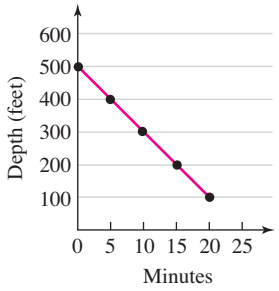
Classify each item as an algebraic expression or an equation.

9. a. $m + 18 = 23$ b. $m + 18$
10. a. $30x$ b. $30x = 600$
11. a. $\dfrac{c - 7}{5}$ b. $\dfrac{c - 7}{5} = 7c$
12. a. $r = \dfrac{2}{3}$ b. $\dfrac{2}{3}r$
13. What arithmetic operations does the expression $\frac{12 + 9t}{25}$ contain? What variable does it contain?
14. What arithmetic operations does the equation $4y - 14 = 5(6)$ contain? What variable does it contain?
15. Construct a line graph using the data in the following table.



Hours worked	Pay (dollars)
1	20
2	40
3	60
4	80
5	100

16. Use the data in the graph to complete the table.



Minutes	Depth (feet)
0	
5	
10	
15	
20	

NOTATION

Fill in the blanks.

17. The symbol $\neq$ means ___ ____ _____ ___.
18. The symbols ( ) are called _____.
19. Write the multiplication 5×6 using a raised dot and then using parentheses.
20. Give four verbs that can be represented by an equal symbol $=$.

Write each expression without using a multiplication symbol or parentheses.

21. $4 \cdot x$
22. $P \cdot r \cdot t$
23. $2(w)$
24. $(x)(y)$

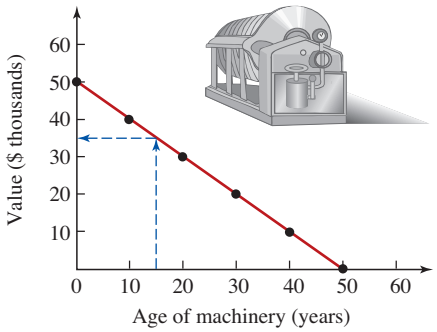
Write each division using a fraction bar.

25. $32 \div x$
26. $30\overline{)90}$
27. $5\overline{)55}$
28. $h \div 15$

GUIDED PRACTICE

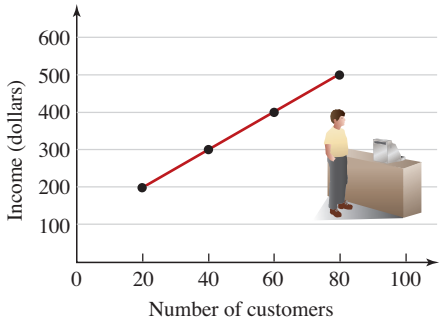
Use the given line graphs to answer the following questions. See Example 1.

29. **Accounting.** Explain what the dashed lines in the graph below help us find.
30. **Accounting.** What is the value of 35-year-old machinery?



31. Business. Refer to the graph below. Find the income received from 30 customers.

32. Business. Refer to the graph below. Find the income received from 70 customers.



***Express each statement using one of the words* sum, product, difference, *or* quotient. See Example 2.**

33. $8(2) = 16$

34. $45 \cdot 12 = 540$

35. $11 - 9 = 2$

36. $65 + 89 = 154$

37. $x + 2 = 10$

38. $16 - t = 4$

39. $\frac{66}{11} = 6$

40. $12 \div 3 = 4$

***Translate each verbal model into an equation. (Answers may vary, depending on the variables chosen.)* See Example 3.**

41. The sale price | is | $100 | minus | the discount.

42. The cost of dining out | equals | the cost of the meal | plus | $7 for parking.

43. 7 | times | the age of a dog in years | gives | the dog's equivalent human age.

44. The number of centuries | is | the number of years | divided by | 100.

45. The amount of sand that should be used is the product of 3 and the amount of cement used.

46. The number of waiters needed is the quotient of the number of customers and 10.

47. The weight of the truck is the sum of the weight of the engine and 1,200.

48. The number of classes still open is the difference of 150 and the number of classes that are closed.

49. The profit is the difference of the revenue and 600.

50. The distance is the product of the rate and 3.

51. The quotient of the number of laps run and 4 gives the number of miles run.

52. The sum of the tax and 35 gives the total cost.

***Use the formula to complete each table.* See Examples 4 and 5.**

53. $d = 360 + L$

Lunch time (minutes) L	School day (minutes) d
30	
40	
45	

54. $b = 1{,}024k$

Kilobytes k	Bytes b
1	
5	
10	

55. $t = 1{,}500 - d$

Deductions d	Take-home pay t
200	
300	
400	

56. $w = \frac{s}{12}$

Inches of snow s	Inches of water w
12	
24	
72	

Use the data in the table to complete the formula.

57. $d = \frac{e}{\square}$

Eggs e	Dozens d
24	2
36	3
48	4

58. $p = \square c$

Canoes c	Paddles p
6	12
7	14
8	16

59. $I = \square c$

Couples c	Individuals I
20	40
100	200
200	400

60. $t = \frac{p}{\square}$

Players p	Teams t
5	1
10	2
15	3

APPLICATIONS

61. Exercise. The number of calories that a 125-pound adult burns doing general house cleaning chores is three times the number of minutes spent cleaning.

a. Write a verbal model using the word *product* that describes the relationship between calories burned and minutes cleaning.

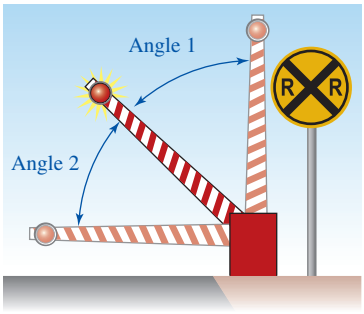
b. Write a formula using the variables c and m that describes the relationship between calories burned and minutes cleaning.

c. Use your answer to part b to complete the following table.

m	10	20	30	40	50	60
c						

d. Use the data from the table to construct a line graph. Scale the horizontal axis in units of 10 minutes. Scale the vertical axis in units of 30 calories.

62. Traffic Safety. As the railroad crossing guard drops, the measure of angle 1 (written $\angle 1$) increases while the measure of $\angle 2$ decreases. At any instant the *sum* of the measures of the two angles is 90°. Complete the table. Then use the data to construct a line graph. Scale each axis in units of 15°.



Angle 1 (degrees)	Angle 2 (degrees)
0	
15	
30	
45	
60	
75	
90	

WRITING

63. Many students misuse the word *equation* when discussing mathematics. What is an equation? Give an example.

64. Explain the difference between an algebraic expression and an equation. Give an example of each.

65. In this section, four methods for describing numerical relationships were discussed: tables, verbal models (words), graphs, and equations. Which method do you think is the most useful? Explain why.

66. In your own words, define *horizontal* and *vertical*.

CHALLENGE PROBLEMS

67. Complete the formula. $t = \square s + \square$

s	t
18	55
33	100
47	142

68. Suppose $h = 4n$ and $n = 2g$. Complete the following formula: $h = \square g$

SECTION 1.2

OBJECTIVES

1. Factor and prime factor natural numbers.
2. Recognize special fraction forms.
3. Multiply and divide fractions.
4. Build equivalent fractions.
5. Simplify fractions.
6. Add and subtract fractions.
7. Simplify answers.
8. Compute with mixed numbers.

The Language of Algebra

When we say "factor 8," we are using the word **factor** as a verb. When we say "2 is a *factor* of 8," we are using the word **factor** as a noun.

Fractions

ARE YOU READY?

The following problems review some basic skills that are needed when working with fractions.

1. What is the value of $\frac{8}{8}$?

2. Multiply: $2 \cdot 3 \cdot 5 \cdot 5$

3. Is 42 divisible by 3?

4. Write the fraction $\frac{4}{5}$ in words.

In arithmetic, we add, subtract, multiply, and divide **natural numbers:** 1, 2, 3, 4, 5, and so on. Assuming that you have mastered those skills, we will now review the arithmetic of fractions.

1 Factor and Prime Factor Natural Numbers.

To compute with fractions, we need to know how to *factor* natural numbers. To **factor** a number means to express it as a product of two or more numbers. For example, some ways to factor 8 are

$$1 \cdot 8, \qquad 4 \cdot 2, \qquad \text{and} \qquad 2 \cdot 2 \cdot 2$$

The numbers 1, 2, 4, and 8 that were used to write the products are called *factors* of 8. In general, a **factor** is a number being multiplied.

Sometimes a number has only two factors, itself and 1. We call such numbers *prime numbers.*