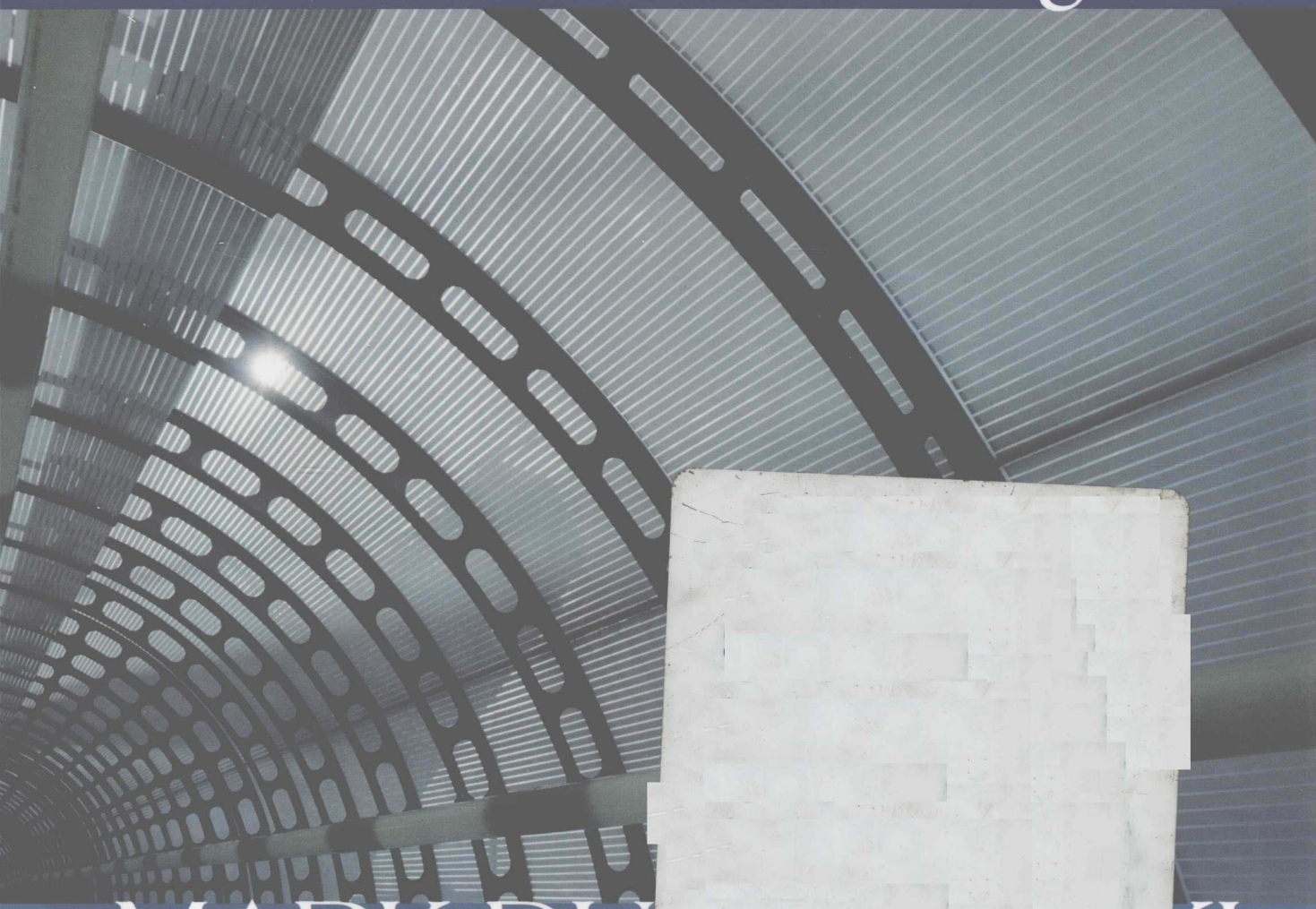
INTERMEDIATE Algebra



MARK DU KI

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Fourth Edition

Intermediate Algebra

EDITION 4

Mark Dugopolski

Southeastern Louisiana University

Higher Education

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PREFACE

Intermediate Algebra, Fourth Edition, is designed to provide students with the algebra background needed for further college-level mathematics courses. The unifying theme of this text is the development of the skills necessary for solving equations and inequalities, followed by the application of those skills to solving applied problems. My primary goal in writing the fourth edition of *Intermediate Algebra* has been to retain the features that made the third edition so successful, while incorporating the comments and suggestions of third-edition users. As always, I endeavor to write texts that students can read, understand, and enjoy, while gaining confidence in their ability to use mathematics. Although a complete development of each topic is provided in *Intermediate Algebra,* Fourth Edition, the text *Elementary Algebra,* Fourth Edition, in this series would be more appropriate for students with no prior experience in algebra.

Content Changes

While the essence of previous editions remains, the topics have been rearranged to reflect the current needs of instructors teaching intermediate algebra courses.

- Functions are introduced in Section 3.5. After that, function topics are revisited where appropriate. For example, polynomial functions appear in Section 5.3, the domain of rational expressions and functions is covered in Section 6.1, and the domain of radical functions is covered in Section 7.1. Functions also appear in Chapter 8, with quadratic equations, and again in Chapters 9 and 10.
- Section 3.5 on functions and relations has been revised with expanded coverage of the concepts of domain and range and the different forms of a function. *Graphs of Functions*, previously Section 3.6, which included graphs of constant functions, quadratic functions, absolute value functions, and square-root functions has been moved to Chapter 9, Section 1.
- The distance and midpoint formulas now appear in Section 3.1, where graphing lines is introduced. The distance formula also appears in Section 11.2, where it is used to develop the equation of a parabola from the geometric definition.
- In Chapter 4, the two sections on determinants and Cramer's rule have been condensed into one, Section 4.5.
- To streamline Chapter 5, the section covering division of polynomials has been moved to Chapter 6 on rational expressions.
- Sections 7.1 and 7.2 have been swapped from the third edition so that radicals now appears as the first topic in Chapter 7, Section 1, and rational exponents now appears in Section 7.2.
- NEW! Transformations of graphs has been added to Chapter 9 and appears in Section 9.2. The section covering the factor theorem has been removed from Chapter 9 and now appears in the companion text *Algebra for College Students,* Third Edition.
- NEW! In Section 11.2, the discussion of parabolas was expanded to include parabolas that open right or left. In Section 11.4 the discussion of hyperbolas was expanded to include hyperbolas that are not centered at the origin.

- NEW! Appendix A Geometry Review has been updated to include review exercises to help students recall geometry concepts and formulas.

In addition to these changes, the text and exercise sets have been carefully revised where necessary. Many new, applied examples have been added to the text and many new, applied exercises have been added to the exercise sets. Particular care has been given to achieving an appropriate balance of problems that progressively increase in difficulty from routine exercises in the beginning of the set to more challenging exercises at the end of the set. As in earlier editions, fractions and decimals are used in the exercises and throughout the text discussions to help reinforce the basic arithmetic skills that are necessary for success in algebra.

Features

- Each chapter begins with a Chapter Opener that discusses a real application of algebra. The discussion is accompanied by a photograph and, in most cases by a real-data application graph that helps students visualize algebra and more fully understand the concepts discussed in the chapter. In addition, each chapter contains a Math at Work feature, which profiles a real person and the mathematics that he or she uses on the job. These two features have corresponding real data exercises.
- The fourth edition continues to emphasize real-data applications that involve graphs. Applications appear throughout the text to help demonstrate concepts, motivate students, and to give students practice using new skills. Many of the real-data exercises contain data obtained from the Internet. Internet addresses are provided as a resource for both students and teachers. An Index of Selected Applications listing applications by subject matter is included at the front of the text.
- Every section begins with In This Section, a list of topics that shows the student what will be covered. Because the topics correspond to the headings within each section, students will find it easy to locate and study specific concepts.
- Important ideas, such as definitions, rules, summaries, and strategies, are set apart in boxes for quick reference. Color is used to highlight these boxes as well as other important points in the text.
- The fourth edition contains margin features that appear throughout the text:

  Calculator Close-ups give students an idea of how and when to use a graphing calculator. Some Calculator Close-ups simply introduce the features of a graphing calculator, where others enhance understanding of algebraic concepts. For this reason, many of the Calculator Close-ups will benefit even those students who do not use a graphing calculator. A graphing calculator is not required for studying from this text.

  Study Tips are included in the margins throughout the text. These short tips are meant to continually reinforce good study habits and to remind students that it is never too late to make improvements in the manner in which they study.

  Helpful Hints are short comments that enhance the material in the text, provide another way of approaching a problem, or clear up misconceptions.

- At the end of every section are Warm-up exercises, a set of ten simple statements that are to be answered true or false. These exercises are designed to provide a smooth transition between the ideas and the exercise sets. They help students understand that every statement in mathematics is either true or false. They are also good for discussion or group work.

- Most section-ending exercise sets in the fourth edition begin with six simple writing exercises. These exercises are designed to get students to review the definitions and rules of the section before doing more traditional exercises. For example, the student might simply be asked what properties of equality were discussed in this section.
- The end-of-section Exercises follow the same order as the textual material and contain exercises that are keyed to examples, as well as numerous exercises that are not keyed to examples. This organization enables the instructor to cover only part of a section if necessary and easily determine which exercises are appropriate to assign. The *keyed exercises* give the student a place to start practicing and building confidence, whereas the *nonkeyed exercises* are designed to wean the student from following examples in a step-by-step manner. *Getting More Involved exercises* are designed to encourage *writing, discussion, exploration,* and *cooperative learning*. *Graphing Calculator exercises* require a graphing calculator and are identified with a graphing calculator logo. Exercises for which a scientific calculator would be helpful are identified with a scientific calculator logo. Please refer to page xxiii for a visual guide of the icons.
- Every chapter ends with a four-part Wrap-up, which includes the following:

  The chapter Summary lists important concepts along with brief illustrative examples.

  Enriching Your Mathematical Word Power appears at the end of each chapter and consists of multiple-choice questions in which the important terms are to be matched with their meanings. This feature emphasizes the importance of proper terminology.

  The Review Exercises contain problems that are keyed to the sections of the chapter as well as numerous miscellaneous exercises.

  The Chapter Test is designed to help the student assess his or her readiness for a test. The Chapter Test has no keyed exercises, thus encouraging the student to work independently of the sections and examples.

- **UPDATED!** At the end of each chapter is a Collaborative Activities feature that is designed to encourage interaction and learning in groups. Many of the Collaborative Activities for the fourth edition have been updated. Instructions and suggestions for using these activities and answers to all problems can be found in the Instructor's Solutions Manual.
- Making Connections, at the end of Chapters 2–12, are cumulative exercises designed to help students review and synthesize new material with ideas from previous chapters, and in some cases, review material necessary for success in upcoming chapters. Every Making Connections exercise set includes at least one applied exercise that requires ideas from one or more of the previous chapters.

Topic Reinforcement

Several methods are employed in this text to help students retain what they learn and expand and build upon previously learned concepts. Most notably, the Making Connections appear at the end of each chapter, beginning with Chapter 2. Making Connections are cumulative sets of exercises that help students to continually practice what they learn. Also, functions are introduced in Section 3.5 and revisited

where appropriate throughout the text. This constant reinforcement helps students retain and strengthen their understanding of this important concept. The distance formula is covered in Section 3.1 and reviewed in Section 11.2 where it is used to develop the equations of the conic sections. In Chapter 9, solving quadratics by factoring and the square root property are reviewed prior to the new ideas of completing the square and the quadratic formula. Through these, and similar methods, students retain what they learn and apply what they learn to new concepts.

Supplements for the Instructor

ANNOTATED INSTRUCTOR'S EDITION

This ancillary includes answers to all section ending exercises, review exercises, Making Connections exercises, and chapter tests. Each answer is printed next to each problem on the page where the problem appears. The answers are printed in a second color for ease of use by instructors.

INSTRUCTOR'S TESTING AND RESOURCE CD-ROM

This CD-ROM contains a computerized test bank that utilizes Brownstone Diploma® testing software. The computerized test bank enables instructors to create well-formatted quizzes or tests using a large bank of algorithmically generated and static questions. When creating a quiz or test, the user can manually choose individual questions or have the software randomly select questions based on section, question type, difficulty level, and other criteria. Instructors also have the ability to add or edit test bank questions to create their own customized test bank. In addition to printed tests, the test generator can deliver tests over a local area network or the World Wide Web, with automatic grading.

Also available on the CD-ROM are pre-formatted tests that appear in two forms: Adobe Acrobat (pdf) and Microsoft Word files. These files are provided for convenient access to "ready to use" tests. The tests can also be downloaded as a Word (.doc) file or can be viewed and printed as a (.pdf) file at www.mhhe.com/dugopolski.

INSTRUCTOR'S SOLUTIONS MANUAL

Prepared by Mark Dugopolski, this supplement contains detailed worked solutions to all of the exercises in the text. The solutions are based on by the techniques used in the text. Instructions and suggestions for using the Collaborative Activities feature in the text are also included in the Instructor's Solutions Manual.

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Supplements for the Student

STUDENT'S SOLUTIONS MANUAL

Prepared by Mark Dugopolski, the *Student's Solutions Manual* contains complete worked-out solutions to all of the odd-numbered exercises in the text. It also contains solutions for all exercises in the Chapter Tests. It may be purchased from McGraw-Hill.

DUGOPOLSKI VIDEO SERIES (Videotapes or CD-ROMs)

The videos are text-specific and cover all chapters of the text. The videos feature an instructor who introduces topics and works through selected problems from the exercise sets. Students are encouraged to work the problems on their own and to check their results with those provided.

DUGOPOLSKI TUTORIAL CD-ROM

This interactive CD-ROM is a self-paced tutorial specifically linked to the text that reinforces topics through unlimited opportunities to review concepts and practice problem solving. The CD-ROM contains algorithmically generated chapter-, and section-specific questions. It requires virtually no computer training on the part of students and supports Windows and Macintosh computers.

ONLINE LEARNING CENTER

The Online Learning Center (OLC), located at www.mhhe.com/dugopolski, contains resources for students and instructors.

Through the Instructor Resource Site, instructors can access links to professional resources, a PowerPoint presentation (transparencies), printable tests, group projects, and a link to PageOut.

To access the Instructor Resource Site, instructors must have a passcode that can be obtained by contacting a McGraw-Hill Higher Education representative.

The Student Learning Site is also passcode-protected. Passcodes for students can be found at the front of their texts when newly purchased. *Passcodes are available free to students when they purchase a new text.* Students also have access to algorithmically generated "bookmarkable" practice exercises (including hints), section- and chapter-level testing, audiovisual tutorials, interactive applications, and links to NetTutor™ and other interesting websites.

The Information Center can be accessed by students and instructors without a passcode. Through the Information Center, users can access general information about the text and its supplements.

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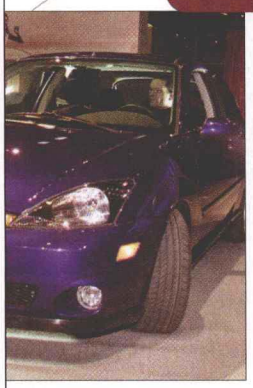
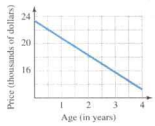
Hammond, Louisiana M.D.

CHAPTER 3



Linear Equations and Inequalities in Two Variables



The first self-propelled automobile to carry passengers was built in 1801 by the British inventor Richard Trevithick. By 1911 about 600,000 automobiles were operated in the United States alone. Some were powered by steam and some by electricity, but most were powered by gasoline. In 1913, to meet the ever growing demand, Henry Ford increased production by introducing a moving assembly line to carry automobile parts. Today the United States is a nation of cars. Over 11 million automobiles are produced here annually, and total car registrations number over 114 million.

Prices for new cars rise every year. Today the most basic Ford Focus sells for $13,000 to $15,000, whereas Henry Ford's early model T sold for $850. Unfortunately, the moment you buy your new car its value begins to decrease. Much of the behavior of automobile prices can be modeled with linear equations. In Exercises 81 and 82 of Section 3.1 you will use linear equations to find increasing new car prices and depreciating used car prices.

Chapter Opener

Each **chapter opener** features a real-world situation that can be modeled using mathematics. Each chapter contains exercises that relate back to the chapter opener.

Find all intercepts for each line. Some of these lines have only one intercept.

67. $3x - 5y = 15$

68. $9x + 8y = 72$

69. $y = 5x$

70. $y = -4x$

71. $6x + 3 = 0$

72. $40x + 5 = 0$

73. $12 + 18y = 0$

74. $2 - 10y = 0$

75. $2 - 4y = 8x$

76. $9x + 3 = 12y$

Complete the given ordered pairs so that each ordered pair satisfies the given equation.

77. $(2, \quad), (\quad, -3), \quad y = -3x + 6$

78. $(-1, \quad), (\quad, 4), \quad y = \frac{1}{2}x + 2$

79. $(-4, \quad), (\quad, 6), \quad \frac{1}{2}x - \frac{1}{3}y = 9$

80. $(3, \quad), (\quad, -1), \quad 2x - 3y = 5$

Solve each problem. See Examples 8 and 9.

81. ***Camaro inflation.*** The rising list price P (in dollars) for a new Camaro Z28 Coupe can be modeled by the equation $P = 320n + 22{,}765$, where n is the number of years since 2000 (www.edmunds.com).
a) What will be the list price for a new Z28 Coupe in 2008?
b) What is the annual increase in list price?
c) Graph the equation for $0 \le n \le 10$.

82. ***Camaro Z28 depreciation.*** The 2002 average retail price P (in dollars) for an n-year-old Camaro Z28 Coupe can be modeled by the equation $P = 23{,}405 - 2{,}530n$, where $0 \le n \le 4$ (www. edmunds.com).
a) What was the average retail price of a 4-year-old Z28 in 2002?
b) How much does this model depreciate each year?
c) Graph the equation for $0 \le n \le 4$.

83. ***Rental cost.*** For a one-day car rental the X-press Car Company charges C dollars, where C is determined by the formula $C = 0.26m + 42$ and m is the number of miles driven.
a) What is the charge for a car driven 400 miles?
b) Sketch a graph of the equation for m ranging from 0 to 1000.

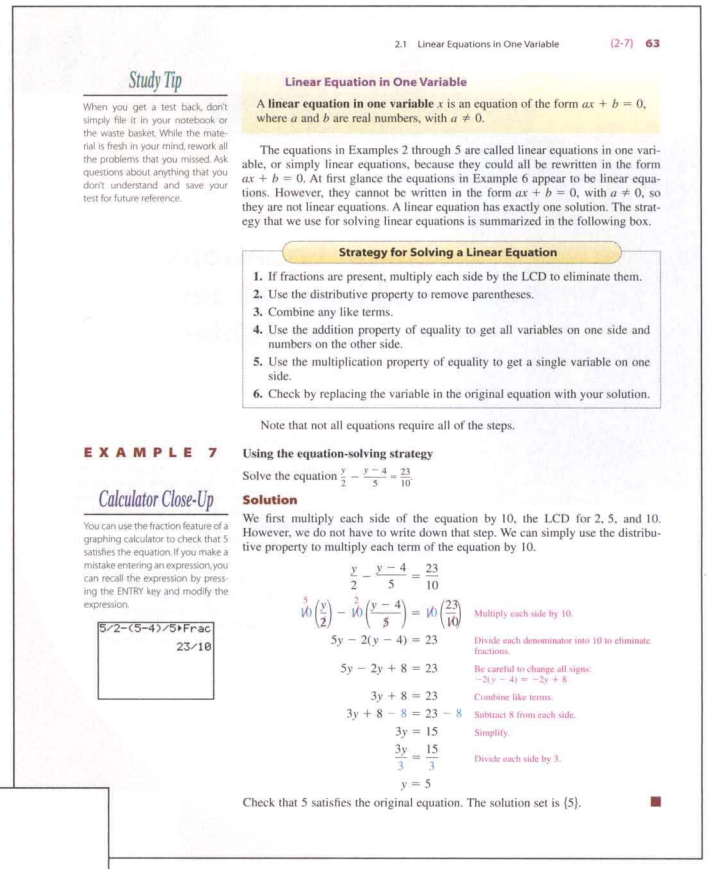
84. ***Measuring risk.*** The Friendly Bob Loan Company gives each applicant a rating, r, from 0 to 10 according to the applicant's ability to repay, a higher rating indicating higher risk. The interest rate, r, is then determined by the formula $r = 0.02t + 0.15$.
a) If your rating were 8, then what would be your interest rate?
b) Sketch the graph of the equation for t ranging from 0 to 10.

85. ***Little Chicago pizza.*** The equation $C = 0.50t + 8.95$ gives the customer's cost in dollars for a pan pizza, where t is the number of toppings.
a) Find the cost of a five-topping pizza.
b) Find t if $C = 14.45$ and interpret your result.

86. ***Long distance charges.*** The formula $L = 0.10n + 4.95$ gives the monthly bill in dollars for AT&T's one-rate

Margin Notes

Margin notes include **helpful hints, study tips,** and **calculator close-ups.** The **helpful hints** point out common errors or reminders. The **study tips** provide practical suggestions for improving study habits. The optional **calculator close-ups** provide tips on using a graphing calculator to aid in your understanding of the material. They also include insightful suggestions for increasing calculator proficiency.



2.1 Linear Equations in One Variable (2-7) 63

Study Tip

When you get a test back, don't simply file it in your notebook or the waste basket. While the material is fresh in your mind, rework all the problems that you missed. Ask questions about anything that you don't understand and save your test for future reference.

Linear Equation in One Variable

A **linear equation in one variable** x is an equation of the form $ax + b = 0$, where a and b are real numbers, with $a \neq 0$.

The equations in Examples 2 through 5 are called linear equations in one variable, or simply linear equations, because they could all be rewritten in the form $ax + b = 0$. At first glance the equations in Example 6 appear to be linear equations. However, they cannot be written in the form $ax + b = 0$, with $a \neq 0$, so they are not linear equations. A linear equation has exactly one solution. The strategy that we use for solving linear equations is summarized in the following box.

Strategy for Solving a Linear Equation

1. If fractions are present, multiply each side by the LCD to eliminate them.
2. Use the distributive property to remove parentheses.
3. Combine any like terms.
4. Use the addition property of equality to get all variables on one side and numbers on the other side.
5. Use the multiplication property of equality to get a single variable on one side.
6. Check by replacing the variable in the original equation with your solution.

Note that not all equations require all of the steps.

EXAMPLE 7 **Using the equation-solving strategy**

Solve the equation $\frac{y}{2} - \frac{y-4}{5} = \frac{23}{10}$.

Calculator Close-Up

You can use the fraction feature of a graphing calculator to check that 5 satisfies the equation. If you make a mistake entering an expression, you can recall the expression by pressing the ENTRY key and modify the expression.

```
5/2-(5-4)/5▸Frac
                23/10
```

Solution

We first multiply each side of the equation by 10, the LCD for 2, 5, and 10. However, we do not have to write down that step. We can simply use the distributive property to multiply each term of the equation by 10.

$$\frac{y}{2} - \frac{y-4}{5} = \frac{23}{10}$$

$$10\left(\frac{y}{2}\right) - 10\left(\frac{y-4}{5}\right) = 10\left(\frac{23}{10}\right) \quad \text{Multiply each side by 10.}$$

$$5y - 2(y-4) = 23 \quad \text{Divide each denominator into 10 to eliminate fractions.}$$

$$5y - 2y + 8 = 23 \quad \text{Be careful to change all signs: } -2(y-4) = -2y + 8$$

$$3y + 8 = 23 \quad \text{Combine like terms.}$$

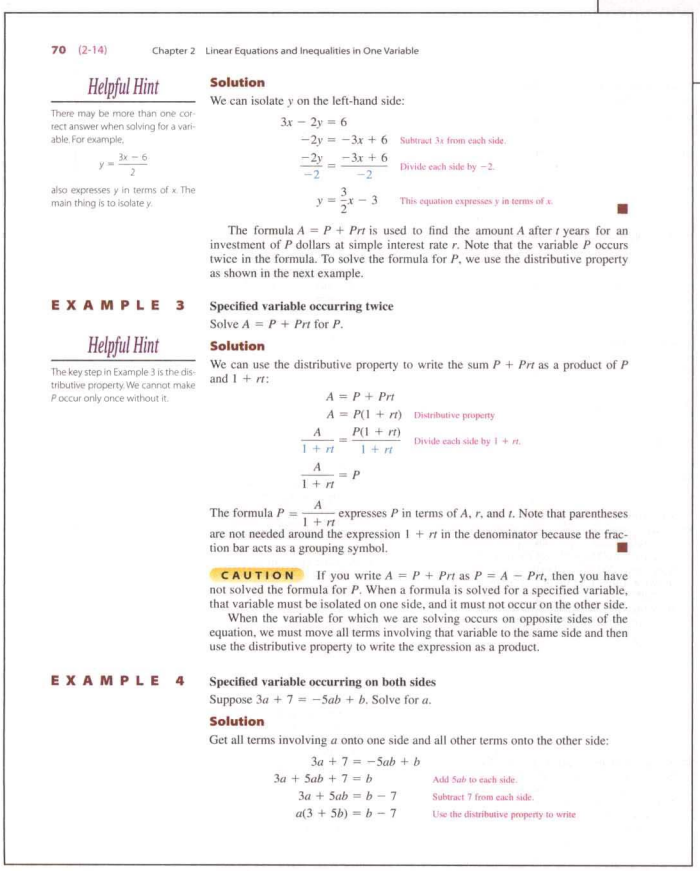
$$3y + 8 - 8 = 23 - 8 \quad \text{Subtract 8 from each side.}$$

$$3y = 15 \quad \text{Simplify.}$$

$$\frac{3y}{3} = \frac{15}{3} \quad \text{Divide each side by 3.}$$

$$y = 5$$

Check that 5 satisfies the original equation. The solution set is $\{5\}$. ■



70 (2-14) Chapter 2 Linear Equations and Inequalities in One Variable

Helpful Hint

There may be more than one correct answer when solving for a variable. For example,

$$y = \frac{3x-6}{2}$$

also expresses y in terms of x. The main thing is to isolate y.

Solution

We can isolate y on the left-hand side:

$$3x - 2y = 6$$

$$-2y = -3x + 6 \quad \text{Subtract } 3x \text{ from each side.}$$

$$\frac{-2y}{-2} = \frac{-3x+6}{-2} \quad \text{Divide each side by } -2.$$

$$y = \frac{3}{2}x - 3 \quad \text{This equation expresses } y \text{ in terms of } x.$$

■

The formula $A = P + Prt$ is used to find the amount A after t years for an investment of P dollars at simple interest rate r. Note that the variable P occurs twice in the formula. To solve the formula for P, we use the distributive property as shown in the next example.

EXAMPLE 3 **Specified variable occurring twice**

Solve $A = P + Prt$ for P.

Helpful Hint

The key step in Example 3 is the distributive property. We cannot make P occur only once without it.

Solution

We can use the distributive property to write the sum $P + Prt$ as a product of P and $1 + rt$:

$$A = P + Prt$$

$$A = P(1 + rt) \quad \text{Distributive property}$$

$$\frac{A}{1+rt} = \frac{P(1+rt)}{1+rt} \quad \text{Divide each side by } 1 + rt.$$

$$\frac{A}{1+rt} = P$$

The formula $P = \frac{A}{1+rt}$ expresses P in terms of A, r, and t. Note that parentheses are not needed around the expression $1 + rt$ in the denominator because the fraction bar acts as a grouping symbol. ■

CAUTION If you write $A = P + Prt$ as $P = A - Prt$, then you have not solved the formula for P. When a formula is solved for a specified variable, that variable must be isolated on one side, and it must not occur on the other side.

When the variable for which we are solving occurs on opposite sides of the equation, we must move all terms involving that variable to the same side and then use the distributive property to write the expression as a product.

EXAMPLE 4 **Specified variable occurring on both sides**

Suppose $3a + 7 = -5ab + b$. Solve for a.

Solution

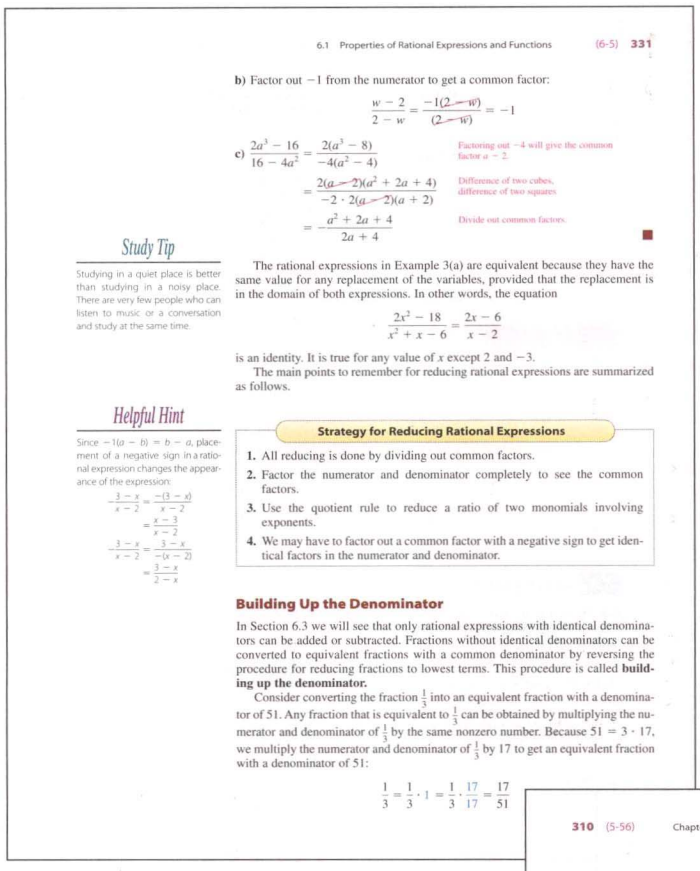
Get all terms involving a onto one side and all other terms onto the other side:

$$3a + 7 = -5ab + b$$

$$3a + 5ab + 7 = b \quad \text{Add } 5ab \text{ to each side.}$$

$$3a + 5ab = b - 7 \quad \text{Subtract 7 from each side.}$$

$$a(3 + 5b) = b - 7 \quad \text{Use the distributive property to write}$$



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b) Factor out -1 from the numerator to get a common factor:

$$\frac{w-2}{2-w} = \frac{-1(2-w)}{(2-w)} = -1$$

c) $\dfrac{2a^3-16}{16-4a^2} = \dfrac{2(a^3-8)}{-4(a^2-4)}$ Factoring out -4 will give the common factor $a-2$.

$= \dfrac{2(a-2)(a^2+2a+4)}{-2\cdot 2(a-2)(a+2)}$ Difference of two cubes, difference of two squares

$= -\dfrac{a^2+2a+4}{2a+4}$ Divide out common factors. ■

Study Tip

Studying in a quiet place is better than studying in a noisy place. There are very few people who can listen to music or a conversation and study at the same time.

The rational expressions in Example 3(a) are equivalent because they have the same value for any replacement of the variables, provided that the replacement is in the domain of both expressions. In other words, the equation

$$\frac{2x^2-18}{x^2+x-6} = \frac{2x-6}{x-2}$$

is an identity. It is true for any value of x except 2 and -3.

The main points to remember for reducing rational expressions are summarized as follows.

Helpful Hint

Since $-1(a-b) = b-a$, placement of a negative sign in a rational expression changes the appearance of the expression:

$$\frac{3-x}{x-2} = \frac{-(3-x)}{x-2} = \frac{x-3}{x-2}$$

$$\frac{3-x}{x-2} = \frac{3-x}{-(x-2)} = \frac{3-x}{2-x}$$

Strategy for Reducing Rational Expressions

1. All reducing is done by dividing out common factors.
2. Factor the numerator and denominator completely to see the common factors.
3. Use the quotient rule to reduce a ratio of two monomials involving exponents.
4. We may have to factor out a common factor with a negative sign to get identical factors in the numerator and denominator.

Building Up the Denominator

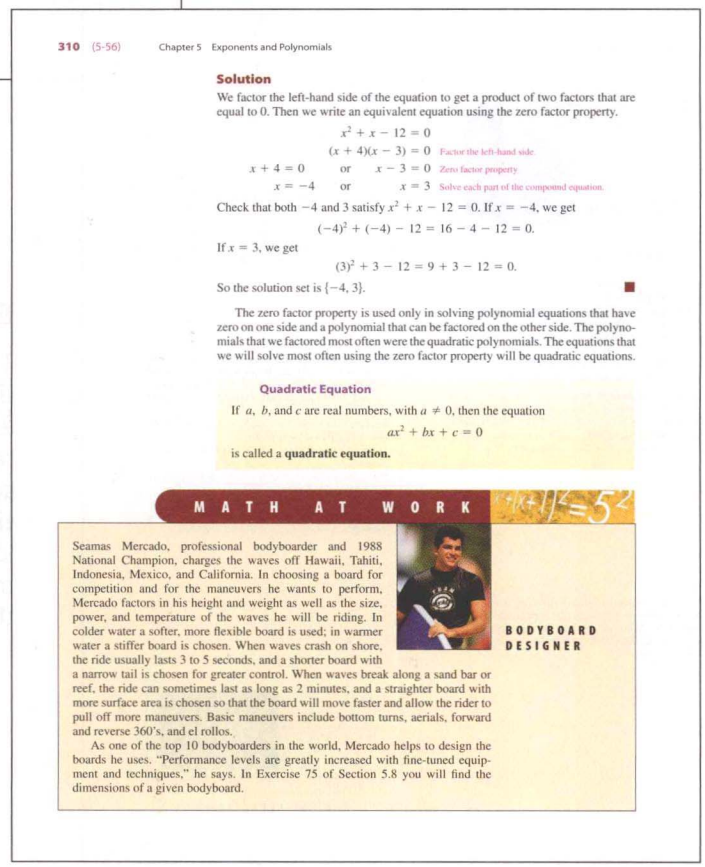
In Section 6.3 we will see that only rational expressions with identical denominators can be added or subtracted. Fractions without identical denominators can be converted to equivalent fractions with a common denominator by reversing the procedure for reducing fractions to lowest terms. This procedure is called **building up the denominator.**

Consider converting the fraction $\frac{1}{3}$ into an equivalent fraction with a denominator of 51. Any fraction that is equivalent to $\frac{1}{3}$ can be obtained by multiplying the numerator and denominator of $\frac{1}{3}$ by the same nonzero number. Because $51 = 3 \cdot 17$, we multiply the numerator and denominator of $\frac{1}{3}$ by 17 to get an equivalent fraction with a denominator of 51:

$$\frac{1}{3} = \frac{1}{3}\cdot 1 = \frac{1}{3}\cdot\frac{17}{17} = \frac{17}{51}$$

Strategy Boxes

The **strategy boxes** provide a numbered list of concepts from a section or a set of steps to follow in problem solving. They can be used by students who prefer a more structured approach to problem solving or they can be used as a study tool to review important points within sections.



310 (5-56) Chapter 5 Exponents and Polynomials

Solution

We factor the left-hand side of the equation to get a product of two factors that are equal to 0. Then we write an equivalent equation using the zero factor property.

$$x^2 + x - 12 = 0$$

$$(x+4)(x-3) = 0$$ Factor the left-hand side.

$x+4=0$ or $x-3=0$ Zero factor property

$x=-4$ or $x=3$ Solve each part of the compound equation.

Check that both -4 and 3 satisfy $x^2 + x - 12 = 0$. If $x = -4$, we get

$$(-4)^2 + (-4) - 12 = 16 - 4 - 12 = 0.$$

If $x = 3$, we get

$$(3)^2 + 3 - 12 = 9 + 3 - 12 = 0.$$

So the solution set is $\{-4, 3\}$. ■

The zero factor property is used only in solving polynomial equations that have zero on one side and a polynomial that can be factored on the other side. The polynomials that we factored most often were the quadratic polynomials. The equations that we will solve most often using the zero factor property will be quadratic equations.

Quadratic Equation

If a, b, and c are real numbers, with $a \neq 0$, then the equation

$$ax^2 + bx + c = 0$$

is called a **quadratic equation.**

MATH AT WORK

BODYBOARD DESIGNER

Seamas Mercado, professional bodyboarder and 1988 National Champion, charges the waves off Hawaii, Tahiti, Indonesia, Mexico, and California. In choosing a board for competition and for the maneuvers he wants to perform, Mercado factors in his height and weight as well as the size, power, and temperature of the waves he will be riding. In colder water a softer, more flexible board is used; in warmer water a stiffer board is chosen. When waves crash on shore, the ride usually lasts 3 to 5 seconds, and a shorter board with a narrow tail is chosen for greater control. When waves break along a sand bar or reef, the ride can sometimes last as long as 2 minutes, and a straighter board with more surface area is chosen so that the board will move faster and allow the rider to pull off more maneuvers. Basic maneuvers include bottom turns, aerials, forward and reverse 360's, and el rollos.

As one of the top 10 bodyboarders in the world, Mercado helps to design the boards he uses. "Performance levels are greatly increased with fine-tuned equipment and techniques," he says. In Exercise 75 of Section 5.8 you will find the dimensions of a given bodyboard.

Math at Work

The **Math at Work** feature that appears in each chapter explores the careers of individuals who use the mathematics presented in the chapter in their work. Students are referred to exercises that directly relate to the occupation highlighted in **Math at Work.**

Note that if one negative sign appears in a fraction, the fraction has the same value whether the negative sign is in the numerator, in the denominator, or in front of the fraction. If the numerator and denominator of a fraction are both negative, then the fraction has a positive value.

Division by Zero

Why do we omit division by zero from the definition of division? If we write $10 \div 0 = c$, we need to find c such that $c \cdot 0 = 10$. But there is no such number. If we write $0 \div 0 = c$, we need to find c such that $c \cdot 0 = 0$. But $c \cdot 0 = 0$ is true for any number c. Having $0 \div 0$ equal to any number would be confusing. Thus $a \div b$ is defined only for $b \neq 0$. Quotients such as

$$5 \div 0, \quad 0 \div 0, \quad \frac{7}{0}, \quad \text{and} \quad \frac{0}{0}$$

are said to be *undefined*.

WARM-UPS

True or false? Explain your answer.

1. The additive inverse of -6 is 6.
2. The opposite of negative 5 is positive 5.
3. The absolute value of 6 is -6.
4. The result of a subtracted from b is the same as $b + (-a)$.
5. If a is positive and b is negative, then ab is negative.
6. If a is positive and b is negative, then $a + b$ is negative.
7. $(-3) - (-6) = -9$
8. $6 \div \left(-\frac{1}{2}\right) = -3$
9. $-3 \div 0 = 0$
10. $0 \div (-7) = 0$

1.3 EXERCISES

Reading and Writing *After reading this section, write out the answers to these questions. Use complete sentences.*

1. What is absolute value?
2. How do you add two numbers with the same sign?
3. How do you add two numbers with unlike signs and different absolute values?
4. What is the relationship between subtraction and addition?
5. How do you multiply signed numbers?
6. What is the relationship between division and multiplication?

Evaluate. See Examples 1 and 2.

7. $|-34|$
8. $|17|$
9. $|0|$
10. $|-15|$
11. $|-6| - |-6|$
12. $|8| - |-8|$
13. $-|-9|$
14. $-|-3|$
15. $-(-9)$
16. $-(-(8))$
17. $-(-(-3))$
18. $-(-(-2))$

Warm-ups

Warm-ups appear before each set of exercises at the end of every section. They are true or false statements that can be used to check conceptual understanding of material within each section.

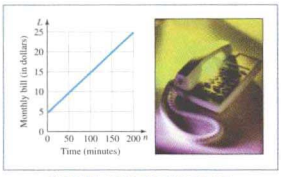


FIGURE FOR EXERCISE 86

plan, where n is the number of minutes of long distance used during the month.

a) Find n if the long distance charge is $23.45.
b) Find L for 120 minutes.
c) Estimate the L-intercept from the accompanying graph.
d) Use the formula to find the L-intercept.
e) Use the formula to find the n-intercept.

87. ***Note pads and binders.*** An office manager is placing an order for note pads at $1 each and binders at $2 each. The total cost of the order must be $100. Write an equation for the total cost and graph it. If he orders 30 note pads, then how many binders must he order?

88. ***Tacos and burritos.*** Jessenda is ordering tacos at $0.75 each and burritos at $2 each for a large group. She must spend $300. Write an equation for the total cost and graph it. If she orders 200 tacos, then how many burritos must she order?

89. ***Cost, revenue, and profit.*** Hillary sells roses at a busy Los Angeles intersection. The formulas

$$C = 0.55x + 50,$$
$$R = 1.50x,$$

and

$$P = 0.95x - 50$$

give her weekly cost, revenue, and profit in terms of x, where x is the number of roses that she sells in one week.

a) Find C, R, and P if $x = 850$. Interpret your results.
b) Find x if $P = 995$ and interpret your result.
c) Find $R - C$ if $x = 1100$ and interpret your result.

90. ***Velocity of a pop up.*** A pop up off the bat of Mark McGwire goes straight into the air at 88 feet per second (ft/sec). The formula $v = -32t + 88$ gives the velocity of the ball in feet per second, t seconds after the ball is hit.

a) Find the velocity for $t = 2$ and $t = 3$ seconds. What does a negative velocity mean?
b) For what value of t is $v = 0$? Where is the ball at this time?
c) What are the two intercepts on the accompanying graph? Interpret this answer.
d) If the ball takes the same time going up as it does coming down, then what is its velocity as it hits the ground?

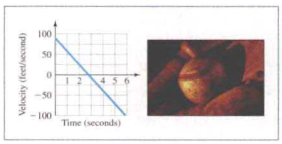


FIGURE FOR EXERCISE 90

Exercises

The theme of mathematics in every day situations is carried over to the exercise sets. Applications based on real-world data are included in each set. The **Index of Selected Applications** can help students to quickly identify exercises that associate the mathematics that may be used in their areas of interest.

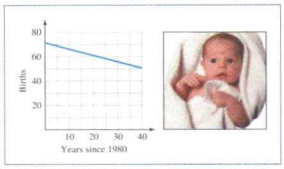


FIGURE FOR EXERCISE 79

where n is the number of years since 1980. What is the first year in which the number of births will be less than 55?

80. ***Bachelor's degrees.*** The number of bachelor's degrees in thousands awarded in the United States can be approximated using the formula

$$B = 16.45n + 980.2,$$

where n is the number of years since 1985 (National Center for Education Statistics, www.nces.ed.gov). What is the first year in which the number of bachelor's degrees will exceed 1.5 million?

81. ***Weighted average.*** Professor Jorgenson gives only a midterm exam and a final exam. The semester average is computed by taking $\frac{1}{3}$ of the midterm exam score plus $\frac{2}{3}$ of the final exam score. The grade is determined from the semester average by using the grading scale given in the table. If Stanley scored only 56 on the midterm, then for what range of scores on the final exam would he get a C or better in the course?

Grading	Scale
90–100	A
80–89	B
70–79	C
60–69	D

TABLE FOR EXERCISES 81 AND 82

82. ***C or better.*** Professor Brown counts her midterm as $\frac{2}{3}$ of the grade and her final as $\frac{1}{3}$ of the grade. Wilbert scored only 56 on the midterm. If Professor Brown also uses the grading scale given in the table, then what range of scores on the final exam would give Wilbert a C or better in the course?

83. ***Designer jeans.*** A pair of ordinary jeans at A-Mart costs $50 less than a pair of designer jeans at Enrico's. In fact, you can buy four pairs of A-Mart jeans for less than one pair of Enrico's jeans. What is the price range for a pair of A-Mart jeans?

84. ***United Express.*** Al and Rita both drive parcel delivery trucks for United Express. Al averages 20 mph less than Rita. In fact, Al is so slow that in 5 hours he covered fewer miles than Rita did in 3 hours. What are the possible values for Al's rate of speed?

GETTING MORE INVOLVED

85. ***Discussion.*** If 3 is added to every number in $(4, \infty)$, the resulting set is $(7, \infty)$. In each of the following cases, write the resulting set of numbers in interval notation. Explain your results.

a) The number -6 is subtracted from every number in $[2, \infty)$.
b) Every number in $(-\infty, -3)$ is multiplied by 2.
c) Every number in $(8, \infty)$ is divided by 4.
d) Every number in $(6, \infty)$ is multiplied by -2.
e) Every number in $(-\infty, -10)$ is divided by -5.

86. ***Writing.*** Explain why saying that x is *at least* 9 is equivalent to saying that x is *greater than or equal to* 9. Explain why saying that x is *at most* 5 is equivalent to saying that x is *less than or equal to* 5.

In This Section

- Basics
- Graphing the Solution Set
- Applications

2.5 COMPOUND INEQUALITIES

In this section we will use the ideas of union and intersection from Chapter 1 along with our knowledge of inequalities from Section 2.4 to work with compound inequalities.

Basics

The inequalities that we studied in Section 2.4 are referred to as **simple inequalities.** If we join two simple inequalities with the con

Getting More Involved appears within selected exercise sets. This feature may contain

Writing,

Cooperative Learning,

Exploration, and/or

Discussion exercises. Each of these components is designed to give students an opportunity to improve and develop the ways in which they express mathematical ideas.

The exercise sets contain exercises that are keyed to examples, as well as exercises that are not keyed to examples.

94. ***Perimeter of a square.*** Find a formula that expresses the perimeter of a square P as a function of the length of its side x.

95. ***Cost of fabric.*** If a certain fabric is priced at $3.98 per yard, express the cost $C(x)$ as a function of the number of yards x. Find $C(3)$.

96. ***Earned income.*** If Mildred earns $14.50 per hour, express her total pay $P(h)$ as a function of the number of hours worked h. Find $P(40)$.

97. ***Cost of pizza.*** A pizza parlor charges $14.95 for a pizza plus $0.50 for each topping. Express the total cost of a pizza $C(n)$ in dollars as a function of the number of toppings n. Find $C(6)$.

98. ***Cost of gravel.*** A gravel dealer charges $50 plus $30 per cubic yard for delivering a truckload of gravel. Express the total cost $C(n)$ in dollars as a function of the number of cubic yards delivered n. Find $C(12)$.

GETTING MORE INVOLVED

99. ***Writing.*** Consider $y = x + 2$ and $y > x + 2$. Explain why one of these relations is a function and the other is not.

100. ***Writing.*** Consider the graphs of $y = 2$ and $x = 3$ in the rectangular coordinate system. Explain why one of these relations is a function and the other is not.

COLLABORATIVE ACTIVITIES

Parallel and Perpendicular Explorations

Grouping: Two students per group
Topic: Graphing linear equations

In this activity you will take turns graphing lines and answering questions about the lines you have graphed. You will need graph paper.

1. Student A will graph the first line $3x - 5y = 15$ and label it line A_1. Label the x- and y-intercepts. Write the equation of the line in slope-intercept form.
2. Student B will graph the second line on the same coordinate system as line A_1. This line will have the same y-intercept as line A_1 and an x-intercept of $(-5, 0)$. Graph this line and label it B_1. Find the equation of line B_1 in both slope-intercept and standard form.
3. Together find the slopes of your lines. Are your lines perpendicular? How do you know?
4. Student A will graph a third line on the same coordinate system. This line must be parallel to line A_1 and pass through the x-intercept of line B_1. Starting at the x-intercept use the slope of A_1 to find a second point. Label your new line A_2. Find and label the y-intercept.
5. Student B will graph the fourth line on the same coordinate system. Starting at the y-intercept of line A_2 use the slope of line B_1 to find a second point. This line will be parallel to line B_1.
6. Together find the equations of lines A_2 and B_2. Write the equations in standard and slope-intercept form. How are the equations similar? How are they different? What geometric shape did your lines make?
7. On a new coordinate system draw a square such that $(0, -3)$ is one vertex of the square and the x- and y-axes are diagonals of the square. Find the equations and slopes of each line segment that forms your square. Verify that some lines are parallel and some are perpendicular.
8. A square is entirely contained in the first quadrant and one of its sides is a line segment with endpoints (1, 3) and (4, 1). What are the other two vertices of the square?

WRAP-UP CHAPTER 3

SUMMARY

Rectangular Coordinate System

		Examples
x-intercept	The point where a nonhorizontal line intersects the x-axis	For the line $2x + y = 6$, the x-intercept is $(3, 0)$ and the y-intercept is $(0, 6)$.
y-intercept	The point where a nonvertical line intersects the y-axis	

Collaborative Activities

Collaborative Activities appear at the end of each chapter. The activities are designed to encourage interaction and learning in a group setting.

Calculator Exercises

Calculator Exercises are optional. They provide an opportunity for students to learn how a scientific or graphing calculator might be useful in solving various problems.

Show a complete solution to each investment problem. See Example 4.

29. ***Investing money.*** Mr. and Mrs. Jackson invested some money at 6% simple interest and some money at 10% simple interest. In the second investment they put $1000 more than they put in the first. If the income from both investments for one year was $340, then how much did they invest at each rate?
30. ***Sibling rivalry.*** Samantha lent her brother some money at 9% simple interest and her sister one-half as much money at 16% simple interest. If she received a total of 34 cents in interest, then how much did she lend to each one?
31. ***Investing inheritance.*** Norman invested one-half of his inheritance in a CD that had a 10% annual yield. He lent one-quarter of his inheritance to his brother-in-law at 12% simple interest. His income from these two investments was $6400 for one year. How much was the inheritance?
32. ***Insurance settlement.*** Gary invested one-third of his insurance settlement in a CD that yielded 12%. He also invested one-third in Tara's computer business. Tara paid Gary 15% on this investment. If Gary's total income from these investments was $10,800 for one year, then what was the amount of his insurance settlement?

Show a complete solution to each mixture problem. See Examples 5 and 6.

33. ***Acid solutions.*** How many gallons of 5% acid solution should be mixed with 20 gallons of a 10% acid solution to obtain an 8% acid solution?
34. ***Alcohol solutions.*** How many liters of a 10% alcohol solution should be mixed with 12 liters of a 20% alcohol solution to obtain a 14% alcohol solution?
35. ***Increasing acidity.*** A gallon of Del Monte White Vinegar is labeled 5% acidity. How many fluid ounces of pure acid must be added to get 6% acidity?
36. ***Chlorine bleach.*** A gallon of Clorox bleach is labeled "5.25% sodium hypochlorite by weight." If a gallon of bleach weighs 8.3 pounds, then how many ounces of sodium hypochlorite must be added so that the bleach will be 6% sodium hypochlorite?

Show a complete solution to each uniform motion problem. See Example 7.

37. ***Driving in a fog.*** Carlo drove for 3 hours in a fog, then increased his speed by 30 miles per hour (mph) and drove 6 more hours. If his total trip was 540 miles, then what was his speed in the fog?
38. ***Walk, don't run.*** Louise walked for 2 hours then ran for $1\frac{1}{2}$ hours. If she runs twice as fast as she walks and the total trip was 20 miles, then how fast does she run?
39. ***Commuting to work.*** A commuter bus takes 2 hours to wntown; an express bus, averaging 25 mph faster, 5 minutes to cover the same route. What is the e speed for the commuter bus?

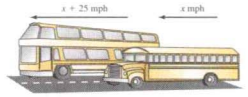


FIGURE FOR EXERCISE 39

40. ***Passengers versus freight.*** A freight train takes $1\frac{1}{3}$ hours to get to the city; a passenger train averaging 40 mph faster takes only 45 minutes to cover the same distance. What is the average speed of the passenger train?

Show a complete solution to each problem. See Example 8.

41. ***Listing a house.*** Karl wants to get $80,000 for his house. The real estate agent charges 8% of the selling price for selling the house. What should the selling price be?
42. ***Hot tamales.*** Martha sells hot tamales at a sidewalk stand. Her total receipts including the 5% sales tax were $915.60. What amount of sales tax did she collect?
43. ***Mustang Sally.*** Sally bought a used Mustang. The selling price plus the 7% state sales tax was $9041.50. What was the selling price?
44. ***Choosing a selling price.*** Roy is selling his car through a broker. Roy wants to get $3000 for himself, but the broker gets a commission of 10% of the selling price. What should the selling price be?

Show a complete solution to each problem.

45. ***Tennis.*** The distance from the baseline to the service line on a tennis court is 3 feet longer than the distance from the service line to the net. If the distance from the

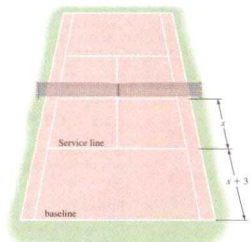


FIGURE FOR EXERCISE 45

64. ***Bonus and taxes.*** A company has an income of $100,000 before paying taxes and a bonus. The bonus B is to be 20% of the income after deducting income taxes T but before deducting the bonus. So

$$B = 0.20(100{,}000 - T).$$

Because the bonus is a deductible expense, the amount of income tax T at a 40% rate is 40% of the income after deducting the bonus. So

$$T = 0.40(100{,}000 - B).$$

a) Use the accompanying graph to estimate the values of T and B that satisfy both equations.

b) Solve the system algebraically to find the bonus and the amount of tax.

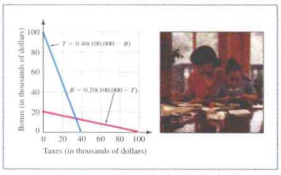


FIGURE FOR EXERCISE 64

65. ***Textbook case.*** The accompanying graph shows the cost of producing textbooks and the revenue from the sale of those textbooks.

a) What is the cost of producing 10,000 textbooks?
b) What is the revenue when 10,000 textbooks are sold?
c) For what number of textbooks is the cost equal to the revenue?
d) The cost of producing zero textbooks is called the *fixed cost*. Find the fixed cost.

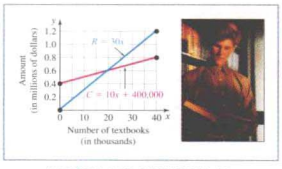


FIGURE FOR EXERCISE 65

66. ***Free market.*** The function $S = 5000 + 200x$ and $D = 9500 - 100x$ express the supply S and the demand D, respectively, for a popular compact disk brand as a function of its price x (in dollars).

a) Graph the functions on the same coordinate system.
b) What happens to the supply as the price increases?
c) What happens to the demand as the price increases?
d) The price at which supply and demand are equal is called the *equilibrium price*. What is the equilibrium price?

GETTING MORE INVOLVED

67. ***Discussion.*** Which of the following equations is not equivalent to $2x - 3y = 6$?

a) $3y - 2x = 6$
b) $y = \frac{2}{3}x - 2$
c) $x = \frac{3}{2}y + 3$
d) $2(x - 5) = 3y - 4$

68. ***Discussion.*** Which of the following equations is inconsistent with the equation $3x + 4y = 8$?

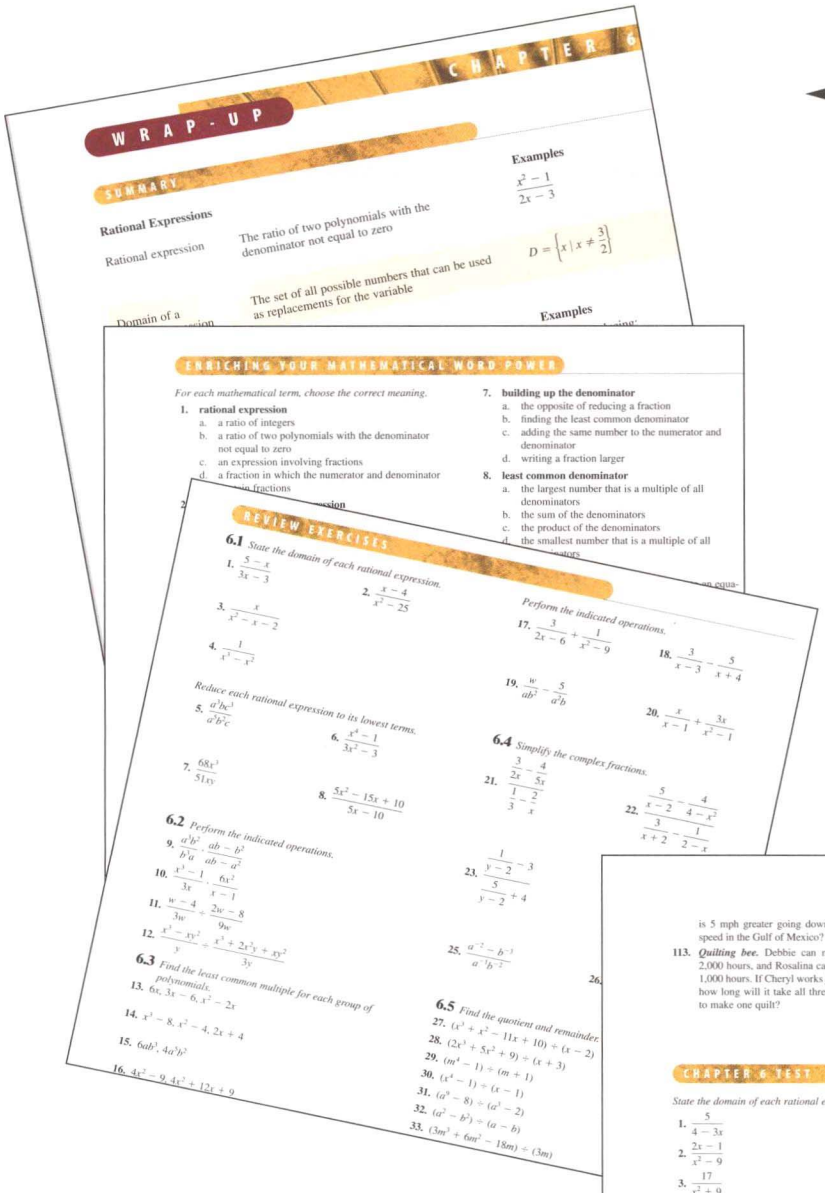
a) $y = \frac{3}{4}x + 2$
b) $6x + 8y = 16$
c) $y = -\frac{3}{4}x + 8$
d) $3x - 4y = 8$

GRAPHING CALCULATOR EXERCISES

69. Solve each system by graphing each pair of equations on a graphing calculator and using the trace feature or intersect feature to estimate the point of intersection. Find the coordinates of the intersection to the nearest tenth.

a) $y = 3.5x - 7.2$
$y = -2.3x + 9.1$

b) $2.3x - 4.1y = 3.3$
$3.4x + 9.2y = 1.3$



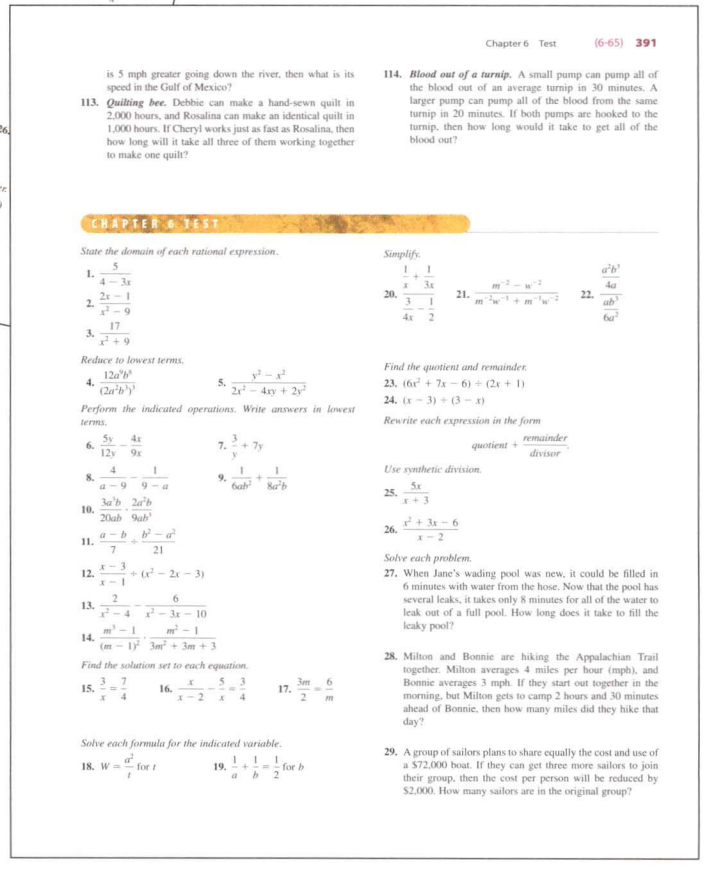
Wrap-up

Every chapter ends with a four-part **Wrap-up:**

The **Summary** lists important concepts along with brief illustrative examples.

Enriching Your Mathematical Word Power enables students to review terms introduced in each chapter. It is intended to help reinforce students' command of mathematical terminology.

Review Exercises contain problems that are keyed to each section of the chapter as well as **miscellaneous exercises,** which are not keyed to the sections. The *miscellaneous exercises* are designed to test the student's ability to synthesize various concepts.

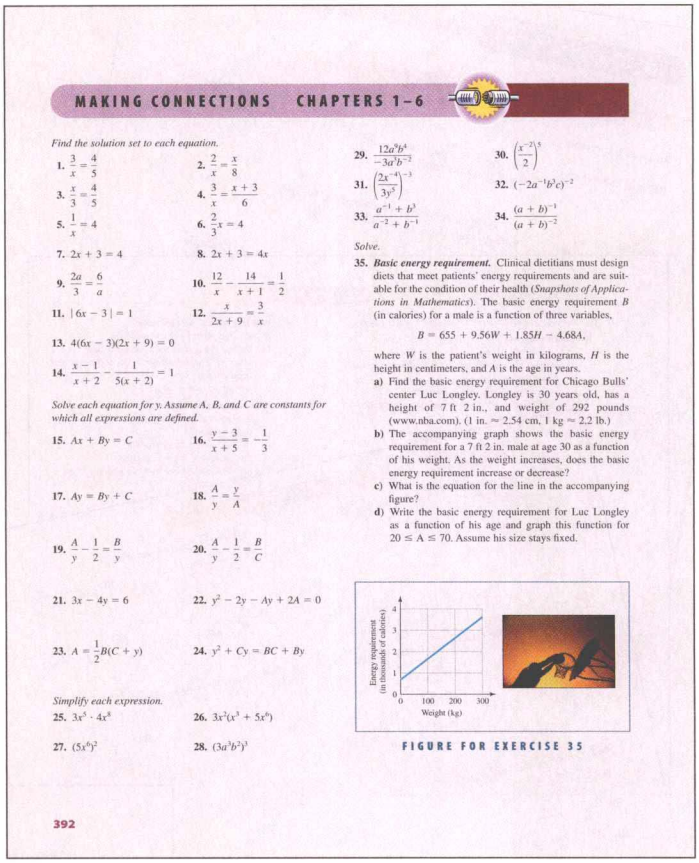


Chapter Test

This is designed to help the student assess his or her readiness for a test. The **Chapter Test** has no keyed exercises, which affords students an opportunity to synthesize concepts found within the chapter.

Making Connections

These nonkeyed exercises are designed to help students synthesize new material with ideas from previous chapters and, in some cases, review material necessary for success in the upcoming chapter. They may serve as a cumulative review.



MAKING CONNECTIONS CHAPTERS 1–6

Find the solution set to each equation.

1. $\frac{3}{x} = \frac{4}{5}$
2. $\frac{2}{x} = \frac{x}{8}$
3. $\frac{x}{3} = \frac{4}{5}$
4. $\frac{3}{x} = \frac{x+3}{6}$
5. $\frac{1}{x} = 4$
6. $\frac{2}{3}x = 4$
7. $2x + 3 = 4$
8. $2x + 3 = 4x$
9. $\frac{2a}{3} = \frac{6}{a}$
10. $\frac{12}{x} - \frac{14}{x+1} = \frac{1}{2}$
11. $|6x - 3| = 1$
12. $\frac{x}{2x+9} = \frac{3}{x}$
13. $4(6x - 3)(2x + 9) = 0$
14. $\frac{x-1}{x+2} - \frac{1}{5(x+2)} = 1$

Solve each equation for y. Assume A, B, and C are constants for which all expressions are defined.

15. $Ax + By = C$
16. $\frac{y-3}{x+5} = -\frac{1}{3}$
17. $Ay = By + C$
18. $\frac{A}{y} = \frac{y}{A}$
19. $\frac{A}{y} - \frac{1}{2} = \frac{B}{y}$
20. $\frac{A}{y} - \frac{1}{2} = \frac{B}{C}$
21. $3x - 4y = 6$
22. $y^2 - 2y - Ay + 2A = 0$
23. $A = \frac{1}{2}B(C + y)$
24. $y^2 + Cy = BC + By$

Simplify each expression.

25. $3x^5 \cdot 4x^8$
26. $3x^2(x^3 + 5x^6)$
27. $(5x^6)^2$
28. $(3a^3b^2)^3$
29. $\frac{12a^5b^4}{-3a^3b^{-2}}$
30. $\left(\frac{x^{-2}}{2}\right)^5$
31. $\left(\frac{2x^{-4}}{3y^2}\right)^{-3}$
32. $(-2a^{-1}b^2c)^{-2}$
33. $\frac{a^{-1} + b^3}{a^{-2} + b^{-1}}$
34. $\frac{(a+b)^{-1}}{(a+b)^{-2}}$

Solve.

35. ***Basic energy requirement.*** Clinical dietitians must design diets that meet patients' energy requirements and are suitable for the condition of their health (*Snapshots of Applications in Mathematics*). The basic energy requirement B (in calories) for a male is a function of three variables,

$$B = 655 + 9.56W + 1.85H - 4.68A,$$

where W is the patient's weight in kilograms, H is the height in centimeters, and A is the age in years.

a) Find the basic energy requirement for Chicago Bulls' center Luc Longley. Longley is 30 years old, has a height of 7 ft 2 in., and weight of 292 pounds (www.nba.com). (1 in. ≈ 2.54 cm, 1 kg ≈ 2.2 lb.)

b) The accompanying graph shows the basic energy requirement for a 7 ft 2 in. male at age 30 as a function of his weight. As the weight increases, does the basic energy requirement increase or decrease?

c) What is the equation for the line in the accompanying figure?

d) Write the basic energy requirement for Luc Longley as a function of his age and graph this function for $20 \le A \le 70$. Assume his size stays fixed.

FIGURE FOR EXERCISE 35

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