ELEMENTARY

gebra

MARK DUGOPOLSKI

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Fourth Edition

Elementary Algebra

EDITION 4

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Southeastern Louisiana University

McGraw-Hill Higher

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To my wife and daughters,
Cheryl, Sarah, and Alisha

PREFACE

Elementary 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 *Elementary 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.

Content Changes

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

- *Systems of Linear Equations and Inequalities*, previously found in Chapter 7 of the third edition, has moved to Chapter 4 in the new edition.
- Chapter 3 has been condensed from seven sections to five. Content from Section 3.5 *Applications of Linear Equations* of the third edition has been incorporated into Section 3.4 *The Point-Slope Form* of the new edition. Section 3.6 *Introduction to Functions* has been moved to Chapter 9, Section 7.
- *Combining Functions* has been newly added to Chapter 9 and appears as the last section.
- The *Geometry Review*, found in Appendix A, now includes a set of Review Exercises.
- Unit conversion problems have been added to Section 2.6.

In addition to these changes, the text and exercise sets have been carefully revised where necessary. New, applied examples have been added to the text and 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 about 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 allows 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 xxi 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.
- The Making Connections exercises at the end of Chapters 2–9 are designed to help students review and synthesize the new material with ideas from previous chapters, and in some cases, review material necessary for success in the upcoming chapter. Every Making Connections exercise set includes at least one applied exercise that requires ideas from one or more of the previous chapters. In essence, the Making Connections are cumulative reviews.

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 preformatted 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. Preformatted chapter tests and final 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 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 can 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. The OLC consists of the Student Learning Site, the Instructor Resource Site, and the Information Center.

Through the Instructor Resource Site, instructors can access links to professional resources, a PowerPoint presentation (transparencies), printable tests, a link to PageOut, and group projects. 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 have access to algorithmically generated "bookmarkable" practice exercises (including hints), section- and chapter-level testing, audiovisual tutorials, interactive applications, and a link 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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NetTutor can be accessed on the Online Learning Center through the Student Learning Site.

Acknowledgments

First of all I thank all of the students and professors who used the previous editions of this text, for without their support there would not be a fourth edition. I sincerely appreciate the efforts of the reviewers who made many helpful suggestions for improving the third edition:

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Hammond, Louisiana M.D.

CHAPTER 3

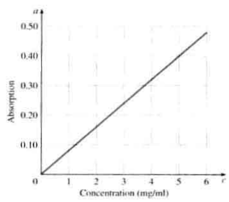
Linear Equations in Two Variables and Their Graphs

If you pick up any package of food and read the label, you will find a long list that usually ends with some mysterious looking names. Many of these strange elements are food additives. A food additive is a substance or a mixture of substances other than basic foodstuffs that is present in food as a result of production, processing, storage, or packaging. They can be natural or synthetic and are categorized in many ways: preservatives, coloring agents, processing aids, and nutritional supplements, to name a few.

Food additives have been around since prehistoric humans discovered that salt would help to preserve meat. Today, food additives can include simple ingredients such as red color from Concord grape skins, calcium, or an enzyme. Throughout the centuries there have been lively discussions on what is healthy to eat. At the present time the food industry is working to develop foods that have less cholesterol, fats, and other unhealthy ingredients.

Although they frequently have different viewpoints, the food industry and the Food and Drug Administration (FDA) are working to provide consumers with information on a healthier diet. Recent developments such as the synthetically engineered tomato stirred great controversy, even though the FDA declared the tomato safe to eat.

In Exercise 79 of Section 3.4 you will see how a food chemist uses a linear equation in testing the concentration of an enzyme in a fruit juice.



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.

3.4 The Point-Slope Form (3-45) **187**

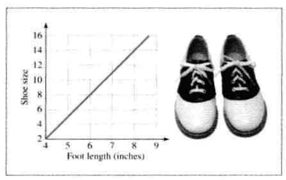


FIGURE FOR EXERCISE 71

72. ***Celsius to Fahrenheit.*** Water freezes at 0°C or 32°F and boils at 100°C or 212°F. There is a linear equation that expresses the number of degrees Fahrenheit (F) in terms of the number of degrees Celsius (C). Find the equation and find the Fahrenheit temperature when the Celsius temperature is 45°.

73. ***Velocity of a projectile.*** A ball is thrown downward from the top of a tall building. Its velocity is 42 feet per second after 1 second and 74 feet per second after 2 seconds. There is a linear equation that expresses the velocity v in terms of the time t. Find the equation and find the velocity after 3.5 seconds.

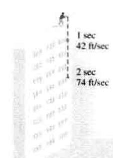


FIGURE FOR EXERCISE 73

74. ***Natural gas.*** The cost of 1000 cubic feet of natural gas is $39 and the cost of 3000 cubic feet is $99. There is a linear equation that expresses the cost C in terms of the number of cubic feet n. Find the equation and find the cost of 2400 cubic feet of natural gas.

75. ***Expansion joint.*** When the temperature is 90°F the width of an expansion joint on a bridge is 0.75 inch. When the temperature is 30°F the width is 1.25 inches. There is a linear equation that expresses the width w in terms of the temperature t.
    a) Find the equation.
    b) What is the width when the temperature is 80°F?
    c) What is the temperature when the width is 1 inch?

76. ***Perimeter of a rectangle.*** A rectangle has a fixed width and a variable length. Let P represent the perimeter and L represent the length. $P = 28$ inches when $L = 6.5$ inches and $P = 36$ inches when $L = 10.5$ inches. There is a linear equation that expresses P in terms of L.
    a) Find the equation.
    b) What is the perimeter when the $L = 40$ inches?
    c) What is the length when $P = 215$ inches?
    d) What is the width of the rectangle?

77. ***Stretching a spring.*** A weight of 3 pounds stretches a spring 1.8 inches beyond its natural length and weight of 5 pounds stretches the same spring 3 inches beyond its natural length. Let A represent the amount of stretch and w the weight. There is a linear equation that expresses A in terms of w. Find the equation and find the amount that the spring will stretch with a weight of 6 pounds.

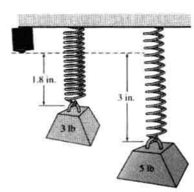


FIGURE FOR EXERCISE 77

78. ***Velocity of a bullet.*** A gun is fired straight upward. The bullet leaves the gun at 100 feet per second (time $t = 0$). After 2 seconds the velocity of the bullet is 36 feet per second. There is a linear equation that gives the velocity v in terms of the time t. Find the equation and find the velocity after 3 seconds.

79. ***Enzyme concentration.*** The amount of light absorbed by a certain liquid depends on the concentration of an enzyme in the liquid. A concentration of 2 milligrams per milliliter (mg/ml) produces an absorption of 0.16 and a concentration of 5 mg/ml produces an absorption of 0.40. There is a linear equation that expresses the absorption a in terms of the concentration c.
    a) Find the equation.
    b) What is the absorption when the concentration is 3 mg/ml?

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.

3.1 Graphing Lines in the Coordinate Plane (3-7) 149

EXAMPLE 5 **Adjusting the scale**

Graph the equation $y = 20x + 500$. Plot at least five points.

Solution

The following table shows five ordered pairs that satisfy the equation.

x	-20	-10	0	10	20
$y = 20x + 500$	100	300	500	700	900

To fit these points onto a graph, we change the scale on the x-axis to let each division represent 10 units and change the scale on the y-axis to let each division represent 200 units. The graph is shown in Fig. 3.9. ■

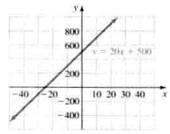


FIGURE 3.9

Graphing a Line Using Intercepts

We know that the graph of a linear equation is a straight line. Because it takes only two points to determine a line, we can graph a linear equation using only two points. The two points that are the easiest to locate are usually the points where the line crosses the axes. The point where the graph crosses the x-axis is the ***x*-intercept,** and the point where the graph crosses the y-axis is the ***y*-intercept.** The x-coordinate of the y-intercept is zero and the y-coordinate of the x-intercept is zero.

EXAMPLE 6 **Graphing a line using intercepts**

Graph the equation $2x - 3y = 6$ by using the x- and y-intercepts.

Solution

To find the x-intercept, let $y = 0$ in the equation $2x - 3y = 6$:

$$2x - 3 \cdot 0 = 6$$
$$2x = 6$$
$$x = 3$$

The x-intercept is $(3, 0)$. To find the y-intercept, let $x = 0$ in $2x - 3y = 6$:

$$2 \cdot 0 - 3y = 6$$
$$-3y = 6$$
$$y = -2$$

The y-intercept is $(0, -2)$. Locate the intercepts and draw a line through them as shown in Fig. 3.10. To check, find one additional point that satisfies the equation, say $(6, 2)$, and see whether the line goes through that point.

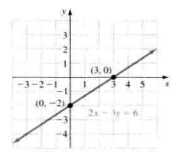


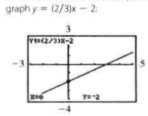
FIGURE 3.10 ■

Helpful Hint

You can find the intercepts for $2x - 3y = 6$ using the *cover-up method.* Cover up $-3y$ with your pencil, then solve $2x = 6$ mentally to get $x = 3$ and an x-intercept of $(3, 0)$. Now cover up $2x$ and solve $-3y = 6$ to get $y = -2$ and a y-intercept of $(0, -2)$.

Calculator Close-Up

To check the result in Example 6, graph $y = (2/3)x - 2$:



Since the calculator graph appears to be the same as the graph in F... 0, it supports the conclusion ...g. 3.10 is correct.

1.2 Fractions (1-15) 15

Study Tip

Read the material in the text before it is discussed in class, even if you do not totally understand it. The classroom discussion will be the second time you have seen the material and it will be easier to question points that you do not understand.

up each denominator to 12:

$$\frac{3}{4} + \frac{1}{6} = \frac{3 \cdot 3}{4 \cdot 3} + \frac{1 \cdot 2}{6 \cdot 2} \quad \text{Build up each denominator to 12.}$$
$$= \frac{9}{12} + \frac{2}{12} \quad \text{Simplify.}$$
$$= \frac{11}{12} \quad \text{Add.}$$

b) The denominators are 12 and 3. Factor 12 as $12 = 2 \cdot 6 = 2 \cdot 2 \cdot 3$. Since 3 is a prime number we do not factor it. Since 2 occurs twice in 12 and not at all in 3, it appears twice in the LCD. Since 3 occurs once in 3 and once in 12, 3 appears once in the LCD. The LCD is $2 \cdot 2 \cdot 3$ or 12. So we must build up $\frac{1}{3}$ to have a denominator of 12:

$$\frac{1}{3} - \frac{1}{12} = \frac{1 \cdot 4}{3 \cdot 4} - \frac{1}{12} \quad \text{Build up the first fraction to the LCD.}$$
$$= \frac{4}{12} - \frac{1}{12} \quad \text{Simplify.}$$
$$= \frac{3}{12} \quad \text{Subtract.}$$
$$= \frac{1}{4} \quad \text{Reduce to lowest terms.}$$

c) Since $12 = 2 \cdot 6 = 2 \cdot 2 \cdot 3$ and $18 = 2 \cdot 9 = 2 \cdot 3 \cdot 3$, the factor 2 appears twice in the LCD and the factor 3 appears twice in the LCD. So the LCD is $2 \cdot 2 \cdot 3 \cdot 3$ or 36:

$$\frac{7}{12} + \frac{5}{18} = \frac{7 \cdot 3}{12 \cdot 3} + \frac{5 \cdot 2}{18 \cdot 2} \quad \text{Build up each denominator to 36.}$$
$$= \frac{21}{36} + \frac{10}{36} \quad \text{Simplify.}$$
$$= \frac{31}{36} \quad \text{Add.}$$

d) To perform addition with the mixed number $2\frac{1}{3}$, first convert it into an improper fraction: $2\frac{1}{3} = 2 + \frac{1}{3} = \frac{6}{3} + \frac{1}{3} = \frac{7}{3}$.

$$2\frac{1}{3} + \frac{5}{9} = \frac{7}{3} + \frac{5}{9} \quad \text{Write } 2\tfrac{1}{3} \text{ as an improper fraction.}$$
$$= \frac{7 \cdot 3}{3 \cdot 3} + \frac{5}{9} \quad \text{The LCD is 9.}$$
$$= \frac{21}{9} + \frac{5}{9} \quad \text{Simplify.}$$
$$= \frac{26}{9} \quad \text{Add.}$$

Note that $\frac{1}{3} + \frac{5}{9} = \frac{3}{9} + \frac{5}{9} = \frac{8}{9}$. Then add on the 2 to get $2\frac{8}{9}$, which is the same as $\frac{26}{9}$. ■

222 (4-18) Chapter 4 Systems of Linear Equations and Inequalities

Now multiply $x + 2y = 24$ by 2 to get $2x + 4y = 48$, and then add:

$$\begin{aligned} 3x - 4y &= 12 \\ 2x + 4y &= 48 \\ \hline 5x \quad &= 60 \\ x &= 12 \end{aligned}$$

Let $x = 12$ in $x + 2y = 24$:

$$\begin{aligned} 12 + 2y &= 24 \\ 2y &= 12 \\ y &= 6 \end{aligned}$$

Check $x = 12$ and $y = 6$ in the original equations. The solution is $(12, 6)$. ■

Use the following strategy to solve a system by addition.

Strategy for Solving a System by Addition

1. Write both equations in standard form.
2. If a variable will be eliminated by adding, then add the equations.
3. If necessary, obtain multiples of one or both equations so that a variable will be eliminated by adding the equations.
4. After one variable is eliminated, solve for the remaining variable.
5. Use the value of the remaining variable to find the value of the eliminated variable.
6. Check the solution in the original system.

Inconsistent and Dependent Systems

When the addition method is used, an inconsistent system will be indicated by a false statement. A dependent system will be indicated by an equation that is always true.

EXAMPLE 5 **Inconsistent and dependent systems**

Use the addition method to solve each system.

a) $-2x + 3y = 9$
$2x - 3y = 18$

b) $2x - y = 1$
$4x - 2y = 2$

Solution

a) Add the equations:

$$\begin{aligned} -2x + 3y &= 9 \\ 2x - 3y &= 18 \\ \hline 0 &= 27 \quad \text{False} \end{aligned}$$

There is no solution to the system. The system is inconsist

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.

90 (2-24) Chapter 2 Linear Equations and Inequalities in One Variable

EXAMPLE 4 **Solving for *y***

Solve $x + 2y = 6$ for y. Write the answer in the form $y = mx + b$, where m and b are fixed real numbers.

Helpful Hint

If we simply wanted to solve $x + 2y = 6$ for y, we could have written

$$y = \frac{6 - x}{2} \text{ or } y = \frac{-x + 6}{2}.$$

However, in Example 4 we requested the form $y = mx + b$. This form is a popular form that we will study in detail in Chapter 3.

Solution

$$\begin{aligned} x + 2y &= 6 && \text{Original equation} \\ 2y &= 6 - x && \text{Subtract } x \text{ from each side.} \\ \frac{1}{2} \cdot 2y &= \frac{1}{2}(6 - x) && \text{Multiply each side by } \tfrac{1}{2} \\ y &= 3 - \frac{1}{2}x && \text{Distributive property} \\ y &= -\frac{1}{2}x + 3 && \text{Rearrange to get } y = mx + b \text{ form.} \end{aligned}$$ ■

Notice that in Example 4 we multiplied each side of the equation by $\frac{1}{2}$, and so we multiplied each term on the right-hand side by $\frac{1}{2}$. Instead of multiplying by $\frac{1}{2}$, we could have divided each side of the equation by 2. We would then divide each term on the right side by 2. This idea is illustrated in Example 5.

MATH AT WORK

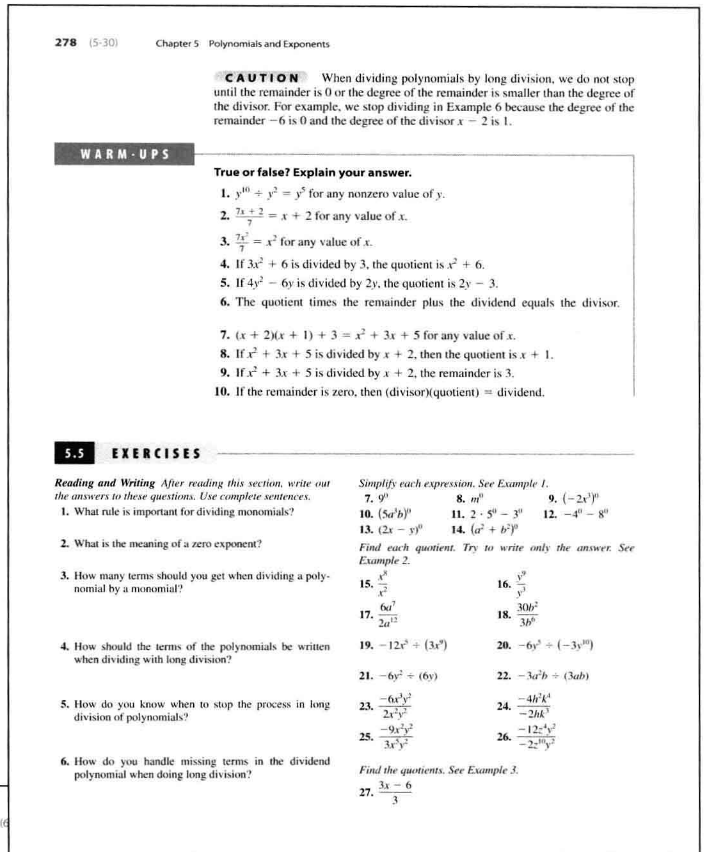
NURSE

Even before the days of Florence Nightingale, nurses around the world were giving comfort and aid to the sick and injured. Continuing in this tradition, Asenet Craffey, staff nurse at the Massachusetts Eye and Ear Infirmary, works in the intensive care unit. During her 12-hour shifts, Ms. Craffey is responsible for the full nursing care of four to eight patients. In the intensive care unit, the nurse-to-patient ratio is usually one to one. When Ms. Craffey is assigned to this unit, she is responsible for over-all care of a patient as well as being prepared for crisis care. Staff scheduling is an additional duty that Ms. Craffey performs, making sure that there is adequate nursing coverage for the day's planned surgeries and quality patient care. Full care means being directly involved in all of the patient's care: monitoring vital signs, changing dressings, helping to feed, following the prescribed orders left by the physicians, and administering drugs.

Many drugs come directly from the pharmacy in the exact dosage for a particular patient. Intravenous (IV) drugs, however, must be monitored so that the correct amount of drops per minute are administered. IV medications can be glucose solutions, antibiotics, or pain killers. Often the prescribed dosage is 1 gram per 100, 200, 500, or 1000 cubic centimeters of liquid. In Exercise 97 of this section you will calculate a drug dosage, just as Ms. Craffey would on the job.

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.**


278 (5-30) Chapter 5 Polynomials and Exponents

CAUTION When dividing polynomials by long division, we do not stop until the remainder is 0 or the degree of the remainder is smaller than the degree of the divisor. For example, we stop dividing in Example 6 because the degree of the remainder -6 is 0 and the degree of the divisor $x - 2$ is 1.

WARM-UPS

True or false? Explain your answer.

1. $y^{10} \div y^2 = y^5$ for any nonzero value of y.
2. $\frac{7x+2}{7} = x + 2$ for any value of x.
3. $\frac{7x^2}{7} = x^2$ for any value of x.
4. If $3x^2 + 6$ is divided by 3, the quotient is $x^2 + 6$.
5. If $4y^2 - 6y$ is divided by $2y$, the quotient is $2y - 3$.
6. The quotient times the remainder plus the dividend equals the divisor.
7. $(x + 2)(x + 1) + 3 = x^2 + 3x + 5$ for any value of x.
8. If $x^2 + 3x + 5$ is divided by $x + 2$, then the quotient is $x + 1$.
9. If $x^2 + 3x + 5$ is divided by $x + 2$, the remainder is 3.
10. If the remainder is zero, then (divisor)(quotient) = dividend.

5.5 EXERCISES

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

1. What rule is important for dividing monomials?
2. What is the meaning of a zero exponent?
3. How many terms should you get when dividing a polynomial by a monomial?
4. How should the terms of the polynomials be written when dividing with long division?
5. How do you know when to stop the process in long division of polynomials?
6. How do you handle missing terms in the dividend polynomial when doing long division?

Simplify each expression. See Example 1.

7. 9^0 8. m^0 9. $(-2x^3)^0$
10. $(5a^3b)^0$ 11. $2 \cdot 5^0 - 3^0$ 12. $-4^0 - 8^0$
13. $(2x - y)^0$ 14. $(a^2 + b^2)^0$

Find each quotient. Try to write only the answer. See Example 2.

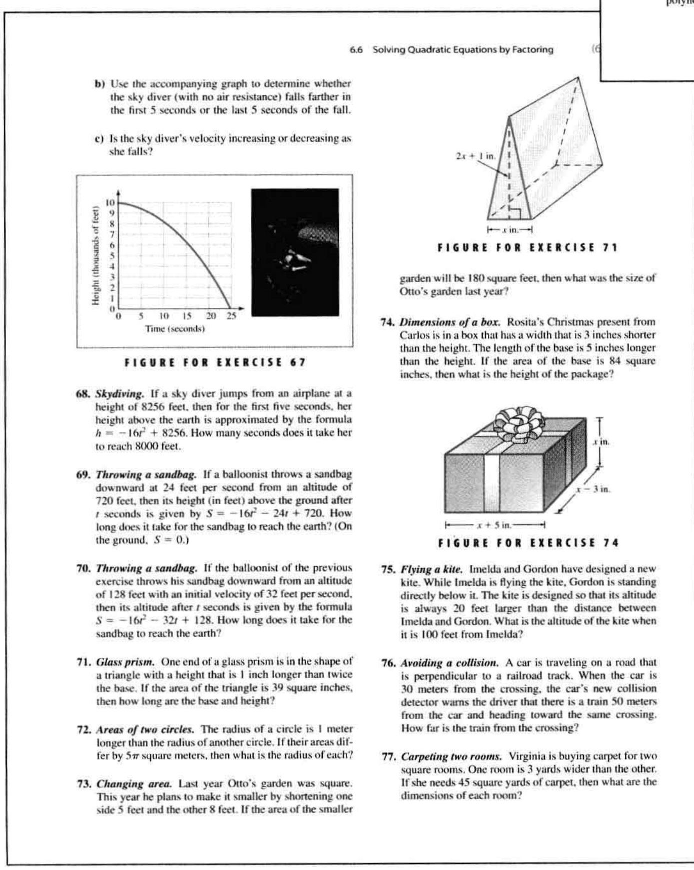
15. $\frac{x^8}{x^2}$ 16. $\frac{y^9}{y^3}$
17. $\frac{6a^7}{2a^{12}}$ 18. $\frac{30b^2}{3b^6}$
19. $-12x^5 \div (3x^9)$ 20. $-6y^5 \div (-3y^{10})$
21. $-6y^2 \div (6y)$ 22. $-3a^2b \div (3ab)$
23. $\frac{-6x^3y^2}{2x^2y^2}$ 24. $\frac{-4h^2k^4}{-2hk^3}$
25. $\frac{-9x^2y^2}{3x^5y^2}$ 26. $\frac{-12z^4y^2}{-2z^{10}y^2}$

Find the quotients. See Example 3.

27. $\frac{3x-6}{3}$

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.


6.6 Solving Quadratic Equations by Factoring

b) Use the accompanying graph to determine whether the sky diver (with no air resistance) falls farther in the first 5 seconds or the last 5 seconds of the fall.

c) Is the sky diver's velocity increasing or decreasing as she falls?

FIGURE FOR EXERCISE 67

68. ***Skydiving.*** If a sky diver jumps from an airplane at a height of 8256 feet, then for the first five seconds, her height above the earth is approximately given by the formula $h = -16t^2 + 8256$. How many seconds does it take her to reach 8000 feet.

69. ***Throwing a sandbag.*** If a balloonist throws a sandbag downward at 24 feet per second from an altitude of 720 feet, then its height (in feet) above the ground after t seconds is given by $S = -16t^2 - 24t + 720$. How long does it take for the sandbag to reach the earth? (On the ground, $S = 0$.)

70. ***Throwing a sandbag.*** If the balloonist of the previous exercise throws his sandbag downward from an altitude of 128 feet with an initial velocity of 32 feet per second, then its altitude after t seconds is given by the formula $S = -16t^2 - 32t + 128$. How long does it take for the sandbag to reach the earth?

71. ***Glass prism.*** One end of a glass prism is in the shape of a triangle with a height that is 1 inch longer than twice the base. If the area of the triangle is 39 square inches, then how long are the base and height?

72. ***Areas of two circles.*** The radius of a circle is 1 meter longer than the radius of another circle. If their areas differ by 5π square meters, then what is the radius of each?

73. ***Changing area.*** Last year Otto's garden was square. This year he plans to make it smaller by shortening one side 5 feet and the other 8 feet. If the area of the smaller garden will be 180 square feet, then what was the size of Otto's garden last year?

FIGURE FOR EXERCISE 71

74. ***Dimensions of a box.*** Rosita's Christmas present from Carlos is in a box that has a width that is 3 inches shorter than the height. The length of the base is 5 inches longer than the height. If the area of the base is 84 square inches, then what is the height of the package?

FIGURE FOR EXERCISE 74

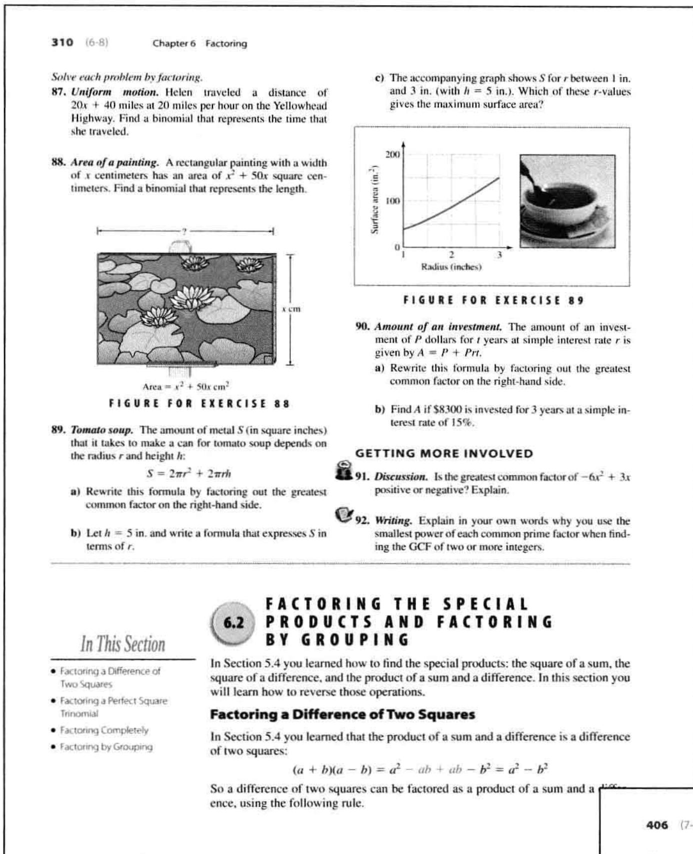
75. ***Flying a kite.*** Imelda and Gordon have designed a new kite. While Imelda is flying the kite, Gordon is standing directly below it. The kite is designed so that its altitude is always 20 feet larger than the distance between Imelda and Gordon. What is the altitude of the kite when it is 100 feet from Imelda?

76. ***Avoiding a collision.*** A car is traveling on a road that is perpendicular to a railroad track. When the car is 30 meters from the crossing, the car's new collision detector warns the driver that there is a train 50 meters from the car and heading toward the same crossing. How far is the train from the crossing?

77. ***Carpeting two rooms.*** Virginia is buying carpet for two square rooms. One room is 3 yards wider than the other. If she needs 45 square yards of carpet, then what are the dimensions of each room?

Exercises

The theme of mathematics in everyday 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.


310 (6-8) Chapter 6 Factoring

Solve each problem by factoring.

87. ***Uniform motion.*** Helen traveled a distance of $20x + 40$ miles at 20 miles per hour on the Yellowhead Highway. Find a binomial that represents the time that she traveled.

88. ***Area of a painting.*** A rectangular painting with a width of x centimeters has an area of $x^2 + 50x$ square centimeters. Find a binomial that represents the length.

?

x cm

Area $= x^2 + 50x$ cm^2

FIGURE FOR EXERCISE 88

89. ***Tomato soup.*** The amount of metal S (in square inches) that it takes to make a can for tomato soup depends on the radius r and height h:

$$S = 2\pi r^2 + 2\pi rh$$

a) Rewrite this formula by factoring out the greatest common factor on the right-hand side.

b) Let $h = 5$ in. and write a formula that expresses S in terms of r.

c) The accompanying graph shows S for r between 1 in. and 3 in. (with $h = 5$ in.). Which of these r-values gives the maximum surface area?

Surface area (in.^{2})

200

100

0

1 2 3

Radius (inches)

FIGURE FOR EXERCISE 89

90. ***Amount of an investment.*** The amount of an investment of P dollars for t years at simple interest rate r is given by $A = P + Prt$.

a) Rewrite this formula by factoring out the greatest common factor on the right-hand side.

b) Find A if \$8300 is invested for 3 years at a simple interest rate of 15%.

GETTING MORE INVOLVED

91. ***Discussion.*** Is the greatest common factor of $-6x^2 + 3x$ positive or negative? Explain.

92. ***Writing.*** Explain in your own words why you use the smallest power of each common prime factor when finding the GCF of two or more integers.

6.2 FACTORING THE SPECIAL PRODUCTS AND FACTORING BY GROUPING

In This Section

- Factoring a Difference of Two Squares
- Factoring a Perfect Square Trinomial
- Factoring Completely
- Factoring by Grouping

In Section 5.4 you learned how to find the special products: the square of a sum, the square of a difference, and the product of a sum and a difference. In this section you will learn how to reverse those operations.

Factoring a Difference of Two Squares

In Section 5.4 you learned that the product of a sum and a difference is a difference of two squares:

$$(a + b)(a - b) = a^2 - ab + ab - b^2 = a^2 - b^2$$

So a difference of two squares can be factored as a product of a sum and a difference, using the following rule.

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

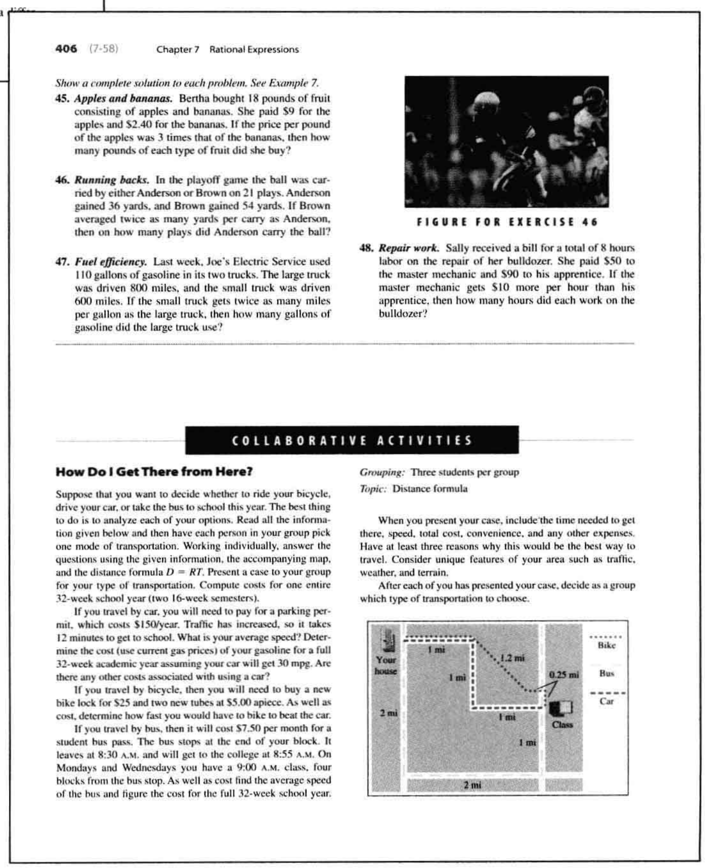
Writing,

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.


406 (7-58) Chapter 7 Rational Expressions

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

45. ***Apples and bananas.*** Bertha bought 18 pounds of fruit consisting of apples and bananas. She paid \$9 for the apples and \$2.40 for the bananas. If the price per pound of the apples was 3 times that of the bananas, then how many pounds of each type of fruit did she buy?

46. ***Running backs.*** In the playoff game the ball was carried by either Anderson or Brown on 21 plays. Anderson gained 36 yards, and Brown gained 54 yards. If Brown averaged twice as many yards per carry as Anderson, then on how many plays did Anderson carry the ball?

47. ***Fuel efficiency.*** Last week, Joe's Electric Service used 110 gallons of gasoline in its two trucks. The large truck was driven 800 miles, and the small truck was driven 600 miles. If the small truck gets twice as many miles per gallon as the large truck, then how many gallons of gasoline did the large truck use?

FIGURE FOR EXERCISE 46

48. ***Repair work.*** Sally received a bill for a total of 8 hours labor on the repair of her bulldozer. She paid \$50 to the master mechanic and \$90 to his apprentice. If the master mechanic gets \$10 more per hour than his apprentice, then how many hours did each work on the bulldozer?

COLLABORATIVE ACTIVITIES

How Do I Get There from Here?

Grouping: Three students per group
Topic: Distance formula

Suppose that you want to decide whether to ride your bicycle, drive your car, or take the bus to school this year. The best thing to do is to analyze each of your options. Read all the information given below and then have each person in your group pick one mode of transportation. Working individually, answer the questions using the given information, the accompanying map, and the distance formula $D = RT$. Present a case to your group for your type of transportation. Compute costs for one entire 32-week school year (two 16-week semesters).

If you travel by car, you will need to pay for a parking permit, which costs \$150/year. Traffic has increased, so it takes 12 minutes to get to school. What is your average speed? Determine the cost (use current gas prices) of your gasoline for a full 32-week academic year assuming your car will get 30 mpg. Are there any other costs associated with using a car?

If you travel by bicycle, then you will need to buy a new bike lock for \$25 and two new tubes at \$5.00 apiece. As well as cost, determine how fast you would have to bike to beat the car.

If you travel by bus, then it will cost \$7.50 per month for a student bus pass. The bus stops at the end of your block. It leaves at 8:30 A.M. and will get to the college at 8:55 A.M. On Mondays and Wednesdays you have a 9:00 A.M. class, four blocks from the bus stop. As well as cost find the average speed of the bus and figure the cost for the full 32-week school year.

When you present your case, include the time needed to get there, speed, total cost, convenience, and any other expenses. Have at least three reasons why this would be the best way to travel. Consider unique features of your area such as traffic, weather, and terrain.

After each of you has presented your case, decide as a group which type of transportation to choose.

Your house

1 mi

1.2 mi

1 mi

0.25 mi

2 mi

1 mi

Class

1 mi

2 mi

Bike

Bus

Car

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.

which the supply is equal to the demand, the equilibrium price? See the accompanying figure.

44. ***Tweedle Dum and Dee.*** Tweedle Dum said to Tweedle Dee "The sum of my weight and twice yours is 361 pounds." Tweedle Dee said to Tweedle Dum "Contrariwise the sum of my weight and twice yours is 362 pounds." Find the weight of each.

GRAPHING CALCULATOR EXERCISE

45. ***Life expectancy.*** Since 1950, the life expectancy of a U.S. male born in year x is modeled by the formula

$$y = 0.165x - 256.7,$$

and the life expectancy of a U.S. female born in year x is modeled by

$$y = 0.186x - 290.6$$

(National Center for Health Statistics, www.cdc.gov).

a) Find the life expectancy of a U.S. male born in 1975 and a U.S. female born in 1975.

b) Graph both equations on your graphing calculator for $1950 < x < 2050$.

c) Will U.S. males ever catch up with U.S. females in life expectancy?

d) Assuming that these equations were valid before 1950, solve the system to find the year of birth for which U.S. males and females had the same life expectancy.

In This Section

- Solving a System of Linear Equations by Addition
- Inconsistent and Dependent Systems
- Applications

4.3 THE ADDITION METHOD

In Section 4.2 we solved systems of equations by using substitution. We substituted one equation into the other to eliminate a variable. The addition method of this section is another method for eliminating a variable to solve a system of equations.

Solving a System of Linear Equations by Addition

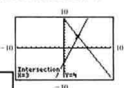
In the substitution method we solve for one variable in terms of the other variable. When doing this, we may get an expression involving fractions, which must be substituted into the other equation. The addition method avoids fractions and is easier to use on certain systems.

EXAMPLE 1 **Solving a system by addition**

Solve: $3x - y = 5$
$2x + y = 10$

Calculator Close-Up

To check Example 1, graph $y_1 = 3x - 5$ and $y_2 = 10 - 2x$. The lines appear to intersect at (3, 4).



Solution

The addition property of equality allows us to add the same number to each side of an equation. If we assume that x and y are numbers that satisfy $3x - y = 5$, then adding these equations is equivalent to adding 5 to each side of $2x + y = 10$:

$$\begin{aligned} 3x - y &= 5 \\ 2x + y &= 10 \quad \text{Add.} \\ 5x \quad &= 15 \quad -y + y = 0 \\ x &= 3 \end{aligned}$$

59. $(0.45)(-365)$ **60.** $8.5 \div (-0.15)$

61. $(-52) \div (-0.034)$ **62.** $(-4.8)(5.6)$

Perform the indicated operations. Use a calculator to check.

63. $(-4)(-4)$ **64.** $-4 - 4$

65. $-4 + (-4)$ **66.** $-4 \div (-4)$

67. $-4 + 4$ **68.** $-4 \cdot 4$

69. $-4 - (-4)$ **70.** $0 \div (-4)$

71. $0.1 - 4$ **72.** $(0.1)(-4)$

73. $(-4) \div (0.1)$ **74.** $-0.1 - 4$

75. $(-0.1)(-4)$ **76.** $-0.1 + 4$

77. $|-0.4|$ **78.** $|0.4|$

79. $\frac{-0.06}{0.3}$ **80.** $\frac{2}{-0.04}$

81. $\frac{3}{-0.4}$ **82.** $\frac{-1.2}{-0.03}$

83. $-\frac{1}{5} + \frac{1}{6}$ **84.** $-\frac{3}{5} - \frac{1}{4}$

85. $\left(-\frac{3}{4}\right)\left(\frac{2}{15}\right)$ **86.** $-1 \div \left(-\frac{1}{4}\right)$

Use a calculator to perform the indicated operations. Round answers to three decimal places.

87. $\frac{45.37}{6}$ **88.** $(-345) \div (28)$

89. $(-4.3)(-4.5)$ **90.** $\frac{-12.34}{-3}$

91. $\frac{0}{6.345}$ **92.** $0 \div (34.51)$

93. $199.4 \div 0$ **94.** $\frac{23.44}{0}$

GETTING MORE INVOLVED

95. ***Discussion.*** If you divide \$0 among five people, how much does each person get? If you divide \$5 among zero people, how much does each person get? What do these questions illustrate?

96. ***Discussion.*** What is the difference between the nonnegative numbers and the positive numbers?

97. ***Writing.*** Why do we learn multiplication of signed numbers before division?

98. ***Writing.*** Try to rewrite the rules for multiplying and dividing signed numbers without using the idea of absolute value. Are your rewritten rules clearer than the original rules?

In This Section

- Arithmetic Expressions
- Exponential Expressions
- The Order of Operations

1.5 EXPONENTIAL EXPRESSIONS AND THE ORDER OF OPERATIONS

In Sections 1.3 and 1.4 you learned how to perform operations with a pair of real numbers to obtain a third real number. In this section you will learn to evaluate expressions involving several numbers and operations.

Arithmetic Expressions

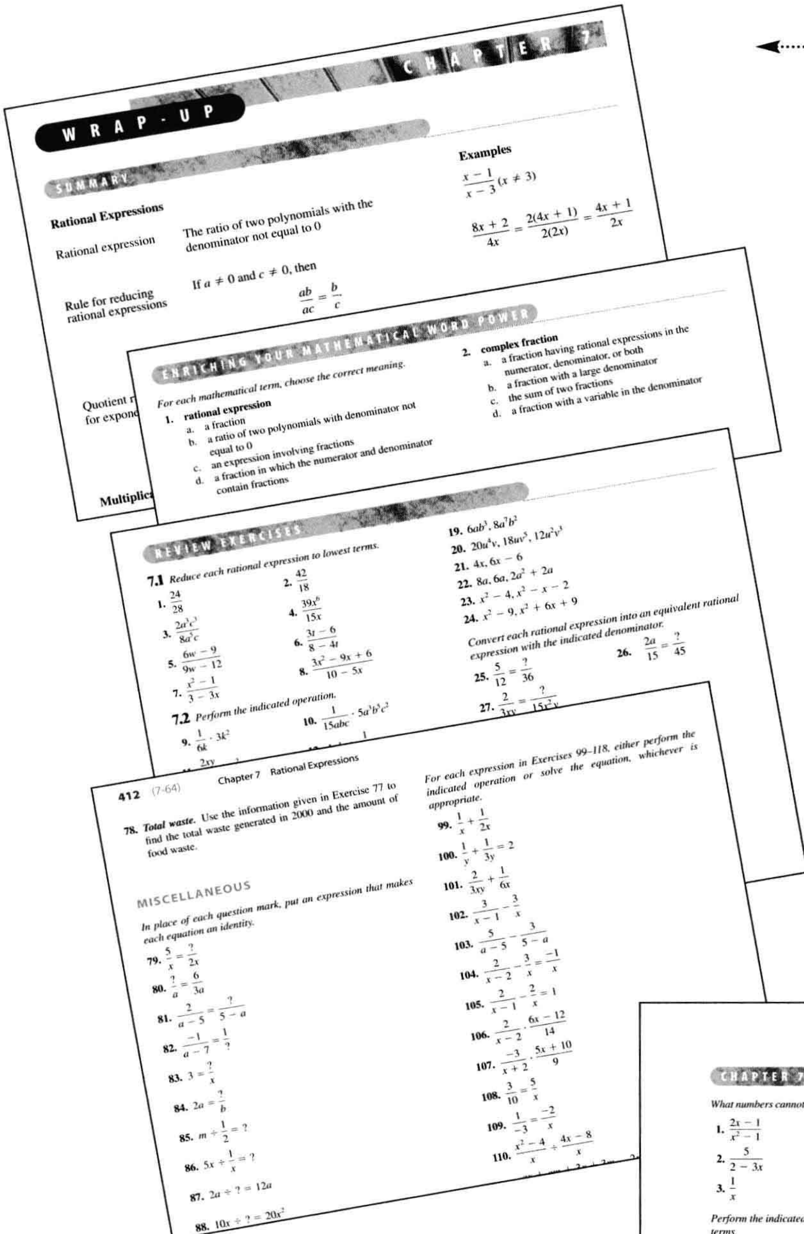
The result of writing numbers in a meaningful combination with the ordinary operations of arithmetic is called an **arithmetic expression** or simply an **expression.** Consider the expressions

$$(3 + 2) \cdot 5 \quad \text{and} \quad 3 + (2 \cdot 5).$$

The parentheses are used as **grouping symbols** and indicate which operation to perform first. Because of the parentheses, these expressions have different values:

$$(3 + 2) \cdot 5 = 5 \cdot 5 = 25$$
$$3 + (2 \cdot 5) = 3 + 10 = 13$$

Absolute value symbols and fraction bars are also used as grouping symbols. The numerator and denominator of a fraction are treated as if each is in parentheses.



CHAPTER 7

WRAP-UP

SUMMARY

Rational Expressions		Examples
Rational expression	The ratio of two polynomials with the denominator not equal to 0	$\frac{x-1}{x-3}\ (x \neq 3)$
Rule for reducing rational expressions	If $a \neq 0$ and $c \neq 0$, then $\frac{ab}{ac} = \frac{b}{c}$	$\frac{8x+2}{4x} = \frac{2(4x+1)}{2(2x)} = \frac{4x+1}{2x}$

Quotient r... for expone...

Multiplic...

ENRICHING YOUR MATHEMATICAL WORD POWER

For each mathematical term, choose the correct meaning.

1. **rational expression**
   a. a fraction
   b. a ratio of two polynomials with denominator not equal to 0
   c. an expression involving fractions
   d. a fraction in which the numerator and denominator contain fractions
2. **complex fraction**
   a. a fraction having rational expressions in the numerator, denominator, or both
   b. a fraction with a large denominator
   c. the sum of two fractions
   d. a fraction with a variable in the denominator

REVIEW EXERCISES

7.1 *Reduce each rational expression to lowest terms.*

1. $\frac{24}{28}$ **2.** $\frac{42}{18}$ **3.** $\frac{2a^3c^3}{8a^5c}$ **4.** $\frac{39x^6}{15x}$ **5.** $\frac{6w-9}{9w-12}$ **6.** $\frac{3t-6}{8-4t}$ **7.** $\frac{x^2-1}{3-3x}$ **8.** $\frac{3x^2-9x+6}{10-5x}$

7.2 *Perform the indicated operation.*

9. $\frac{1}{6k} \cdot 3k^2$ **10.** $\frac{1}{15abc} \cdot 5a^3b^5c^2$

19. $6ab^3, 8a^7b^2$ **20.** $20u^4v, 18uv^5, 12u^2v^3$ **21.** $4x, 6x-6$ **22.** $8a, 6a, 2a^2+2a$ **23.** x^2-4, x^2-x-2 **24.** x^2-9, x^2+6x+9

Convert each rational expression into an equivalent rational expression with the indicated denominator.

25. $\frac{5}{12} = \frac{?}{36}$ **26.** $\frac{2a}{15} = \frac{?}{45}$ **27.** $\frac{2}{3xy} = \frac{?}{15x^2y}$

412 (7-64) Chapter 7 Rational Expressions

78. *Total waste.* Use the information given in Exercise 77 to find the total waste generated in 2000 and the amount of food waste.

MISCELLANEOUS

In place of each question mark, put an expression that makes each equation an identity.

79. $\frac{5}{x} = \frac{?}{2x}$ **80.** $\frac{?}{a} = \frac{6}{3a}$ **81.** $\frac{2}{a-5} = \frac{?}{5-a}$ **82.** $\frac{-1}{a-7} = \frac{1}{?}$ **83.** $3 = \frac{?}{x}$ **84.** $2a = \frac{?}{b}$ **85.** $m \div \frac{1}{2} = ?$ **86.** $5x \div \frac{1}{x} = ?$ **87.** $2a \div ? = 12a$ **88.** $10x \div ? = 20x^2$

For each expression in Exercises 99–118, either perform the indicated operation or solve the equation, whichever is appropriate.

99. $\frac{1}{x} + \frac{1}{2x}$ **100.** $\frac{1}{y} + \frac{1}{3y} = 2$ **101.** $\frac{2}{3xy} + \frac{1}{6x}$ **102.** $\frac{3}{x-1} - \frac{3}{x}$ **103.** $\frac{5}{a-5} - \frac{3}{5-a}$ **104.** $\frac{2}{x-2} - \frac{3}{x} = \frac{-1}{x}$ **105.** $\frac{2}{x-1} - \frac{2}{x} = 1$ **106.** $\frac{2}{x-2} \cdot \frac{6x-12}{14}$ **107.** $\frac{-3}{x+2} \cdot \frac{5x+10}{9}$ **108.** $\frac{3}{10} = \frac{5}{x}$ **109.** $\frac{1}{-3} = \frac{-2}{x}$ **110.** $\frac{x^2-4}{x} \div \frac{4x-8}{x}$

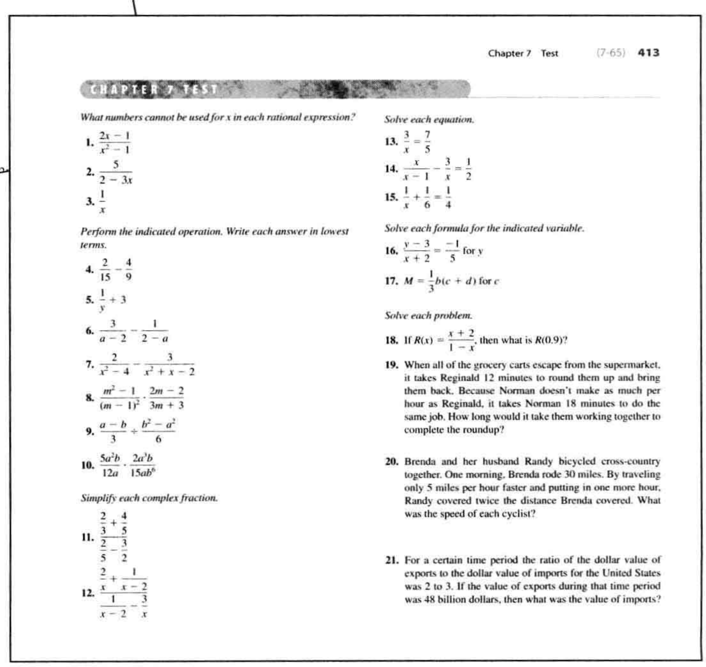
Wrap-Up

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 7 Test (7-65) **413**

CHAPTER 7 TEST

What numbers cannot be used for x in each rational expression?

1. $\frac{2x-1}{x^2-1}$

2. $\frac{5}{2-3x}$

3. $\frac{1}{x}$

Perform the indicated operation. Write each answer in lowest terms.

4. $\frac{2}{15} - \frac{4}{9}$

5. $\frac{1}{y} + 3$

6. $\frac{3}{a-2} - \frac{1}{2-a}$

7. $\frac{2}{x^2-4} - \frac{3}{x^2+x-2}$

8. $\frac{m^2-1}{(m-1)^2} \cdot \frac{2m-2}{3m+3}$

9. $\frac{a-b}{3} \div \frac{b^2-a^2}{6}$

10. $\frac{5a^2b}{12a} \cdot \frac{2a^3b}{15ab^6}$

Simplify each complex fraction.

11. $\dfrac{\frac{2}{3}+\frac{4}{5}}{\frac{2}{5}-\frac{3}{2}}$

12. $\dfrac{\frac{2}{x}+\frac{1}{x-2}}{\frac{1}{x-2}-\frac{3}{x}}$

Solve each equation.

13. $\frac{3}{x} = \frac{7}{5}$

14. $\frac{x}{x-1} - \frac{3}{x} = \frac{1}{2}$

15. $\frac{1}{x} + \frac{1}{6} = \frac{1}{4}$

Solve each formula for the indicated variable.

16. $\frac{y-3}{x+2} = \frac{-1}{5}$ for y

17. $M = \frac{1}{3}b(c+d)$ for c

Solve each problem.

18. If $R(x) = \frac{x+2}{1-x}$, then what is $R(0.9)$?

19. When all of the grocery carts escape from the supermarket, it takes Reginald 12 minutes to round them up and bring them back. Because Norman doesn't make as much per hour as Reginald, it takes Norman 18 minutes to do the same job. How long would it take them working together to complete the roundup?

20. Brenda and her husband Randy bicycled cross-country together. One morning, Brenda rode 30 miles. By traveling only 5 miles per hour faster and putting in one more hour, Randy covered twice the distance Brenda covered. What was the speed of each cyclist?

21. For a certain time period the ratio of the dollar value of exports to the dollar value of imports for the United States was 2 to 3. If the value of exports during that time period was 48 billion dollars, then what was the value of imports?

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.