BEGINNING ALGEBRA

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Graw Hill Higher Education

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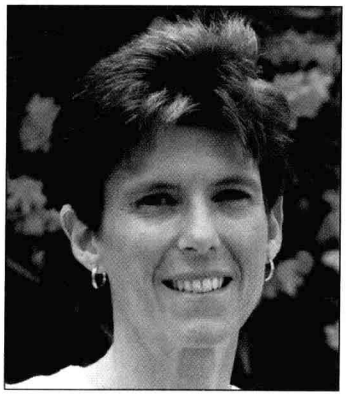
Dedication

To Geoff and Pam, and Joelle and Bob
—Julie Miller

To my parents, Doris and Richard Krajewski
—Molly O'Neill

About the Authors



JULIE MILLER

Julie Miller has been a member of the Mathematics Department at Daytona Beach Community College for 14 years where she has taught developmental and upper level courses. Prior to her work at DBCC, Julie worked as a software engineer for General Electric in the area of flight and radar simulation. Julie earned a bachelor of science degree in applied mathematics from Union College in Schenectady, New York and a master of science in mathematics from the University of Florida. In addition to her textbook, Julie has authored several course supplements for college algebra, trigonometry, and precalculus and several short works of fiction and nonfiction for young readers.

MOLLY O'NEILL

Molly O'Neill is also from Daytona Beach Community College where she has taught for 16 years in the Mathematics Department. She has taught a variety of courses from developmental mathematics to calculus. Before she came to Florida, Molly taught as an adjunct instructor at the University of Michigan—Dearborn, Eastern Michigan University, Wayne State University, and Oakland Community College. Molly earned a bachelor of science degree in mathematics and a master of arts and teaching from Western Michigan University in Kalamazoo, Michigan. Besides her textbook, Molly has authored several course supplements for college algebra, trigonometry, and precalculus and reviewed texts for developmental mathematics.

HELP YOURSELF

To succeed in mathematics, as in any subject, you must be willing to devote some of your time and attention to completing homework assignments and preparing for exams. You must set aside time for yourself on a regular basis to put any classroom notes to use and work through homework exercises. As you study your notes and work on homework, you may find that some concepts are easier to understand than others. For this reason, you may need to have a concept explained more than once or in different ways. Outside of the explanations you may receive in the classroom or from tutors, this textbook and its accompanying products will provide you with additional explanations, worked examples, and exercise sets to help you master concepts and practice what you learn. If you use the resources available to you, with a little self-discipline and patience you should find that you achieve a passing grade in the course and build the groundwork necessary for further studies in mathematics.

SUPPLEMENTS FOR THE STUDENT

The following products were developed in conjunction with your textbook to offer you additional support in your course.

Student Learning Site—Online Learning Center

The Student Learning Site of the Online Learning Center (OLC), located at www.mhhe.com/miller_oneill contains valuable resources that will help you improve your understanding of the topics presented in your course.

The Student Learning Site is passcode-protected. A passcode can be found at the front of your newly purchased text and *is free when you purchase a new text.*

When you enter the Student Learning Site, you will find materials for a Student Portfolio, a downloadable formula card, access to NetTutor™, access to tutorials, and more!

NetTutor

NetTutor is a revolutionary system that enables you to interact with a live tutor over the World Wide Web by using NetTutor's Web-based, graphical chat capabilities. You can also submit questions and receive answers, browse previously answered questions, and view previous live chat sessions. You can access the NetTutor environment from home or school, regardless of the Internet browser or computer you are using, as long as the computer has a modem and a connection to the Internet.

To learn more about NetTutor and to register, visit the Student Learning Site of the Online Learning Center.

Miller/O'Neill Tutorial CD-ROM

The interactive CD-ROM that accompanies *Beginning Algebra* 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 provides section-specific animated lessons with accompanying audio, practice exercises that enable you to work through problems with step-by-step guidance available, concept-matching problems that test vocabulary skills as well as identification of properties and rules, and more. This browser-based CD requires virtually no computer training and will run on both Windows and Macintosh computers. The CD-ROM is available free to students who purchase a *new* text.

Miller/O'Neill Video Series (Videotapes or Video CDs)

The video series is based on problems taken directly from the Practice Exercises. The Practice Exercises contain icons that show which problems from the text appear in the video series. A mathematics instructor presents selected problems and works through them, following the solution methodology employed in the text. The video series is also available on video CDs.

Student's Solutions Manual

The *Student's Solutions Manual* contains comprehensive, worked-out solutions to the odd-numbered exercises in the Practice Exercise sets, the Midchapter Reviews, the end-of-chapter Review Exercises, the Chapter Tests and the Cumulative Review Exercises.

PUTTING IT ALL TOGETHER

This text and its accompanying supplements have been designed to offer you the kind of support that will help you succeed in your course. Here are a few suggestions for using the text and its accompanying materials.

To prepare for exams, rework assigned homework problems to practice. Also, work through the Chapter Tests and compare your answers with those in the back of the text. You can use the Student Portfolio, available on the Student Learning Site of the Online Learning Center, to keep your notes and other class-related papers such as quizzes and tests organized. If you save your tests, you can rework problems from the test in preparation for other exams. You can also use the Vocabulary Worksheets from the Student Portfolio to review terms that might appear on any of your quizzes or exams.

If you are looking for extra help and are not able to get help in school due to conflicting schedules with your instructor or tutoring center, you can use NetTutor. The Student Learning Site of the Online Learning Center contains many other valuable elements such as "e-professors." The e-professors are tutorials based on topics selected from each section of the text. These tutorials present worked-out solutions to problems, similar to those found in your text. Another valuable source of help is the Video Series. If you cannot attend a class on a particular day or if you would just like more explanation, refer to the selected problems from the Practice Exercises of your text that have a video icon. Once you identify these problems, you can use the videotapes or videos on CD to watch an instructor present the solutions.

The *Student's Solutions Manual* for the text is another way to obtain worked-out solutions for problems in your text if you would like a reminder or a hint as to how various problems are solved.

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Finally, we give special thanks to all the students and instructors who use *Beginning Algebra* in their classes.

Julie Miller and Molly O'Neill

KEY FEATURES

To get the most use out of your textbook, take a few minutes to familiarize yourself with its features.

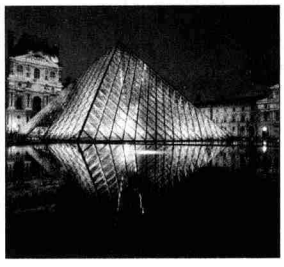
Chapter Openers

Each chapter opens with an application relating to topics presented in the chapter. The Chapter Openers also contain website references for **Technology Connections**—Internet activities found in the Student Learning Site of the Online Learning Center—that further the scope of the application.

chapter

8

RADICALS



The area of a triangle can be found if the length of one side (the base) and the corresponding height of the triangle are known.

$$A = \frac{1}{2}bh$$

However, if the height of a triangle is not known, but the lengths of the three sides, a, b, and, c are given, the area of the triangle can be found using Heron's formula:

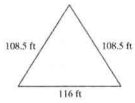
$$A = \sqrt{s(s-a)(s-b)(s-c)}$$

where

$$s = \frac{1}{2}(a+b+c)$$

Heron's formula and other applications of radicals are studied in this chapter.

The Louvre pyramid, designed by architect I. M. Pei, is a glass structure that serves as the entrance to the Louvre Museum in Paris. Each triangular face is made of glass with dimensions as shown.



The area of each face can be found using Heron's formula:

$$s = \frac{1}{2}(108.5 + 108.5 + 116) = 166.5$$

$$A = \sqrt{166.5(166.5-108.5)(166.5-108.5)(166.5-116)} \approx 5318.4$$

The area of each triangular face required approximately 5318.4 ft^2 of glass.

section

3.1 Exponents: Multiplying and Dividing Common Bases

Concepts

1. Review of Exponential Notation

Recall that an **exponent** is used to show repeated multiplication of the **base**.

Definition of b^n

Let b represent any real number and n represent a positive integer. Then,

$$b^n = \underbrace{b \cdot b \cdot b \cdot b \cdot \ldots \cdot b}_{n \text{ factors of } b}$$

example 1 **Evaluating Expressions with Exponents**

For each expression, identify the exponent and base. Then evaluate the expression.

a. 6^2 b. $\left(-\frac{1}{2}\right)^3$ c. 0.8^4

Solution:

Expression	Base	Exponent	Result
a. 6^2	6	2	$(6)(6) = 36$
b. $\left(-\frac{1}{2}\right)^3$	$-\frac{1}{2}$	3	$\left(-\frac{1}{2}\right)\left(-\frac{1}{2}\right)\left(-\frac{1}{2}\right) = -\frac{1}{8}$
c. 0.8^4	0.8	4	$(0.8)(0.8)(0.8)(0.8) = 0.4096$

Note that if no exponent is explicitly written for an expression, then the expression has an implied exponent of 1. For example,

$$x = x^1$$
$$y = y^1$$
$$5 = 5^1$$

2. Evaluating Expressions with Exponents

Recall from Section 1.2 that particular care must be taken when evaluating exponential expressions involving negative numbers. An exponential expression with a negative base is written with parentheses around the base, such as $(-3)^2$.

To evaluate $(-3)^2$, we have: $(-3)^2 = (-3)(-3) = 9$

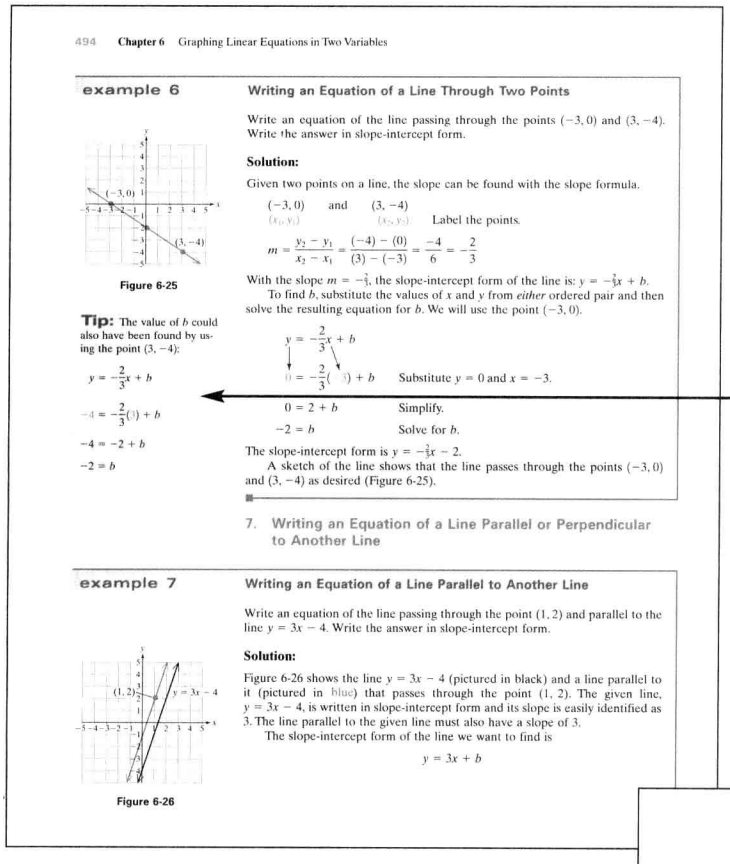
If no parentheses are present, the expression -3^2, is the *opposite* of 3^2, or equivalently, $-1 \cdot 3^2$.

Hence: $-3^2 = -1(3^2) = -1(3)(3) = -9$

Special Elements

Concepts

A list of important concepts is provided at the beginning of each section. Each concept corresponds to a heading within the section, making it easy to locate topics as you study or work through homework exercises.



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example 6 **Writing an Equation of a Line Through Two Points**

Write an equation of the line passing through the points $(-3, 0)$ and $(3, -4)$. Write the answer in slope-intercept form.

Solution:

Given two points on a line, the slope can be found with the slope formula.

$(-3, 0)$ and $(3, -4)$
(x_1, y_1) (x_2, y_2) Label the points.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{(-4) - (0)}{(3) - (-3)} = \frac{-4}{6} = -\frac{2}{3}$$

With the slope $m = -\frac{2}{3}$, the slope-intercept form of the line is: $y = -\frac{2}{3}x + b$.

To find b, substitute the values of x and y from *either* ordered pair and then solve the resulting equation for b. We will use the point $(-3, 0)$.

$$y = -\frac{2}{3}x + b$$
$$0 = -\frac{2}{3}(-3) + b \quad \text{Substitute } y = 0 \text{ and } x = -3.$$
$$0 = 2 + b \quad \text{Simplify.}$$
$$-2 = b \quad \text{Solve for } b.$$

The slope-intercept form is $y = -\frac{2}{3}x - 2$.

A sketch of the line shows that the line passes through the points $(-3, 0)$ and $(3, -4)$ as desired (Figure 6-25).

Figure 6-25

Tip: The value of b could also have been found by using the point $(3, -4)$:

$y = -\frac{2}{3}x + b$
$-4 = -\frac{2}{3}(3) + b$
$-4 = -2 + b$
$-2 = b$

7. Writing an Equation of a Line Parallel or Perpendicular to Another Line

example 7 **Writing an Equation of a Line Parallel to Another Line**

Write an equation of the line passing through the point $(1, 2)$ and parallel to the line $y = 3x - 4$. Write the answer in slope-intercept form.

Solution:

Figure 6-26 shows the line $y = 3x - 4$ (pictured in black) and a line parallel to it (pictured in blue) that passes through the point $(1, 2)$. The given line, $y = 3x - 4$, is written in slope-intercept form and its slope is easily identified as 3. The line parallel to the given line must also have a slope of 3.

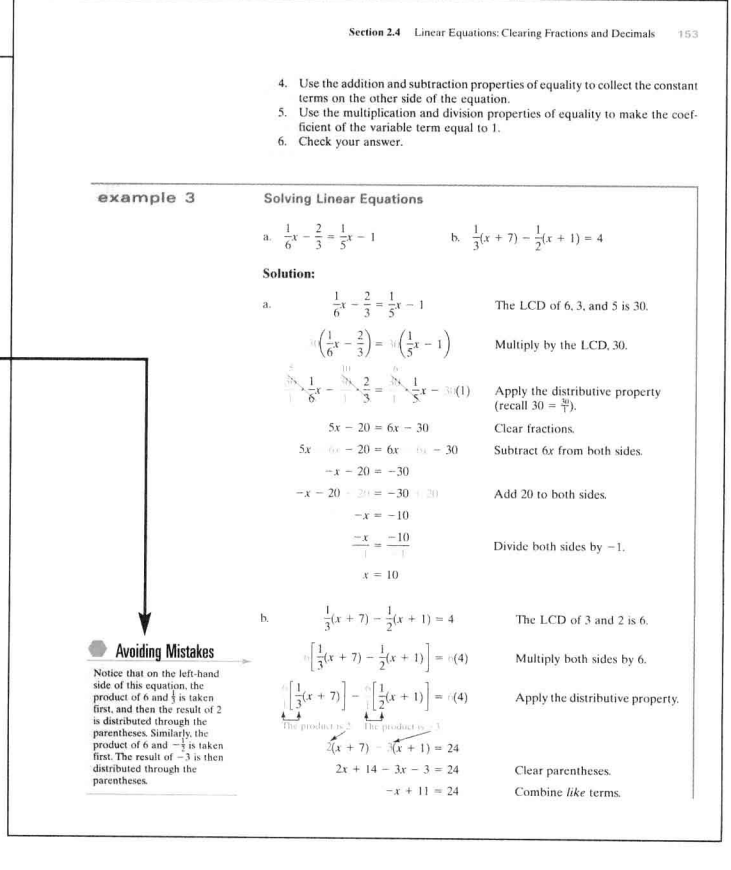
The slope-intercept form of the line we want to find is

$$y = 3x + b$$

Figure 6-26

Tips

Tip boxes appear throughout the text and offer helpful hints and insight.



Section 2.4 Linear Equations: Clearing Fractions and Decimals 153

4. Use the addition and subtraction properties of equality to collect the constant terms on the other side of the equation.
5. Use the multiplication and division properties of equality to make the coefficient of the variable term equal to 1.
6. Check your answer.

example 3 **Solving Linear Equations**

a. $\frac{1}{6}x - \frac{2}{3} = \frac{1}{5}x - 1$ b. $\frac{1}{3}(x + 7) - \frac{1}{2}(x + 1) = 4$

Solution:

a.
$$\frac{1}{6}x - \frac{2}{3} = \frac{1}{5}x - 1 \quad \text{The LCD of 6, 3, and 5 is 30.}$$
$$30\left(\frac{1}{6}x - \frac{2}{3}\right) = 30\left(\frac{1}{5}x - 1\right) \quad \text{Multiply by the LCD, 30.}$$
$$30 \cdot \frac{1}{6}x - 30 \cdot \frac{2}{3} = 30 \cdot \frac{1}{5}x - 30(1) \quad \text{Apply the distributive property (recall } 30 = \tfrac{30}{1}\text{).}$$
$$5x - 20 = 6x - 30 \quad \text{Clear fractions.}$$
$$5x - 6x - 20 = 6x - 6x - 30 \quad \text{Subtract } 6x \text{ from both sides.}$$
$$-x - 20 = -30$$
$$-x - 20 + 20 = -30 + 20 \quad \text{Add 20 to both sides.}$$
$$-x = -10$$
$$\frac{-x}{-1} = \frac{-10}{-1} \quad \text{Divide both sides by } -1.$$
$$x = 10$$

b.
$$\frac{1}{3}(x + 7) - \frac{1}{2}(x + 1) = 4 \quad \text{The LCD of 3 and 2 is 6.}$$
$$6\left[\frac{1}{3}(x + 7) - \frac{1}{2}(x + 1)\right] = 6(4) \quad \text{Multiply both sides by 6.}$$
$$6\left[\frac{1}{3}(x + 7)\right] - 6\left[\frac{1}{2}(x + 1)\right] = 6(4) \quad \text{Apply the distributive property.}$$
The product is 2. The product is 3.
$$2(x + 7) - 3(x + 1) = 24$$
$$2x + 14 - 3x - 3 = 24 \quad \text{Clear parentheses.}$$
$$-x + 11 = 24 \quad \text{Combine } \textit{like} \text{ terms.}$$

Avoiding Mistakes

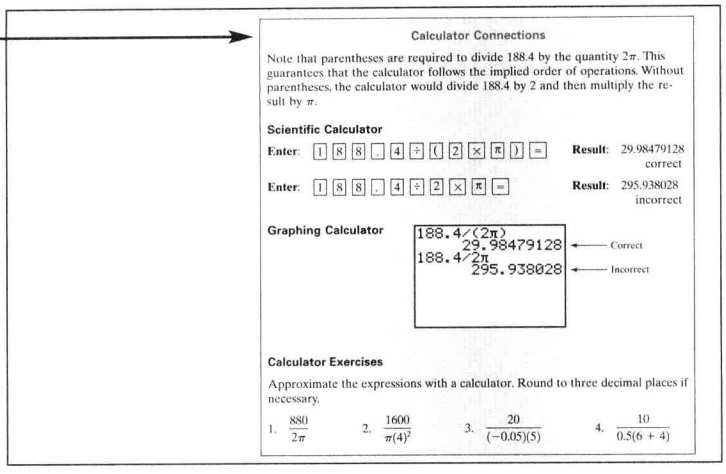
Notice that on the left-hand side of this equation, the product of 6 and $\frac{1}{3}$ is taken first, and then the result of 2 is distributed through the parentheses. Similarly, the product of 6 and $-\frac{1}{2}$ is taken first. The result of -3 is then distributed through the parentheses.

Avoiding Mistakes

Through marginal notes labeled Avoiding Mistakes you are alerted to common errors and are shown methods to avoid them.

Calculator Connections

Optional Calculator Connections boxes, appear throughout the text. These boxes appear for your reference and may be included as part of your reading assignment, depending on the amount of emphasis your instructor places on the calculator in your course. They are designed for use with a scientific and/or a graphing calculator.



Calculator Connections

Note that parentheses are required to divide 188.4 by the quantity 2π. This guarantees that the calculator follows the implied order of operations. Without parentheses, the calculator would divide 188.4 by 2 and then multiply the result by π.

Scientific Calculator

Enter: [1] [8] [8] [.] [4] [÷] [(] [2] [×] [π] [)] [=] **Result:** 29.98479128 correct

Enter: [1] [8] [8] [.] [4] [÷] [2] [×] [π] [=] **Result:** 295.938028 incorrect

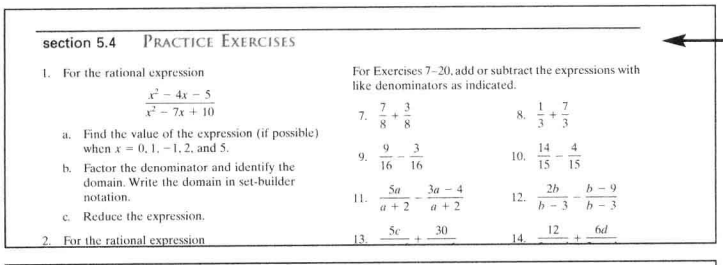
Graphing Calculator

188.4/(2π)
29.98479128 ← Correct
188.4/2π
295.938028 ← Incorrect

Calculator Exercises

Approximate the expressions with a calculator. Round to three decimal places if necessary.

1. $\frac{880}{2\pi}$ 2. $\frac{1600}{\pi(4)^2}$ 3. $\frac{20}{(-0.05)(5)}$ 4. $\frac{10}{0.5(6+4)}$



section 5.4 PRACTICE EXERCISES

1. For the rational expression

$$\frac{x^2 - 4x - 5}{x^2 - 7x + 10}$$

a. Find the value of the expression (if possible) when $x = 0, 1, -1, 2$, and 5.

b. Factor the denominator and identify the domain. Write the domain in set-builder notation.

c. Reduce the expression.

2. For the rational expression

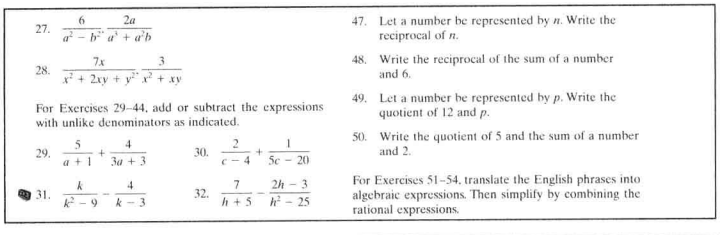
For Exercises 7–20, add or subtract the expressions with like denominators as indicated.

7. $\frac{7}{8} + \frac{3}{8}$ 8. $\frac{1}{3} + \frac{7}{3}$

9. $\frac{9}{16} - \frac{3}{16}$ 10. $\frac{14}{15} - \frac{4}{15}$

11. $\frac{5a}{a+2} - \frac{3a-4}{a+2}$ 12. $\frac{2b}{b-3} - \frac{b-9}{b-3}$

13. $\frac{5c}{\quad} + \frac{30}{\quad}$ 14. $\frac{12}{\quad} + \frac{6d}{\quad}$



27. $\frac{6}{a^2 - b^2} \cdot \frac{2a}{a^2 + a^2 b}$

28. $\frac{7x}{x^2 + 2xy + y^2} \cdot \frac{3}{x^2 + xy}$

For Exercises 29–44, add or subtract the expressions with unlike denominators as indicated.

29. $\frac{5}{a+1} + \frac{4}{3a+3}$ 30. $\frac{2}{c-4} + \frac{1}{5c-20}$

31. $\frac{k}{k^2 - 9} - \frac{4}{k-3}$ 32. $\frac{7}{h+5} - \frac{2h-3}{h^2 - 25}$

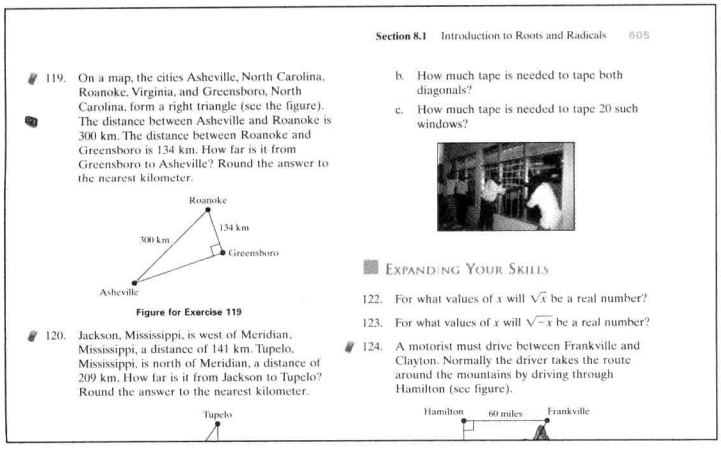
47. Let a number be represented by n. Write the reciprocal of n.

48. Write the reciprocal of the sum of a number and 6.

49. Let a number be represented by p. Write the quotient of 12 and p.

50. Write the quotient of 5 and the sum of a number and 2.

For Exercises 51–54, translate the English phrases into algebraic expressions. Then simplify by combining the rational expressions.



Section 8.1 Introduction to Roots and Radicals 605

119. On a map, the cities Asheville, North Carolina, Roanoke, Virginia, and Greensboro, North Carolina, form a right triangle (see the figure). The distance between Asheville and Roanoke is 300 km. The distance between Roanoke and Greensboro is 134 km. How far is it from Greensboro to Asheville? Round the answer to the nearest kilometer.

Figure for Exercise 119

120. Jackson, Mississippi, is west of Meridian, Mississippi, a distance of 141 km. Tupelo, Mississippi, is north of Meridian, a distance of 209 km. How far is it from Jackson to Tupelo? Round the answer to the nearest kilometer.

Tupelo

b. How much tape is needed to tape both diagonals?

c. How much tape is needed to tape 20 such windows?

EXPANDING YOUR SKILLS

122. For what values of x will $\sqrt{x}$ be a real number?

123. For what values of x will $\sqrt{-x}$ be a real number?

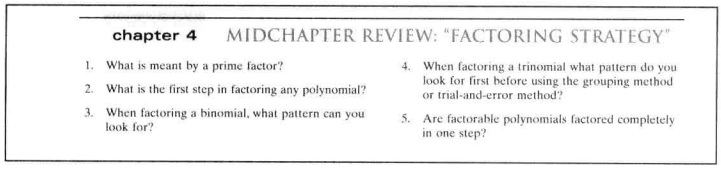
124. A motorist must drive between Frankville and Clayton. Normally the driver takes the route around the mountains by driving through Hamilton (see figure).

Hamilton 60 miles Frankville

Practice Exercises

The Practice Exercises contain a variety of problem types.

- **Applications** are based on real-world facts and figures. Working through these problems will help you improve your problem-solving skills.
- **Exercises Keyed to Video** are labeled with an icon to help you identify those exercises that appear in the video series that accompanies this text.
- **Calculator Exercises** present situations when a calculator can be used to help you perform calculations that might be overly time-consuming if done by hand. They are designed for use with either a scientific or a graphing calculator.
- **Expanding Your Skills**, found near the end of most Practice Exercise sets, are exercises that challenge your knowledge of the concepts presented.



chapter 4 MIDCHAPTER REVIEW: "FACTORING STRATEGY"

1. What is meant by a prime factor?
2. What is the first step in factoring any polynomial?
3. When factoring a binomial, what pattern can you look for?
4. When factoring a trinomial what pattern do you look for first before using the grouping method or trial-and-error method?
5. Are factorable polynomials factored completely in one step?

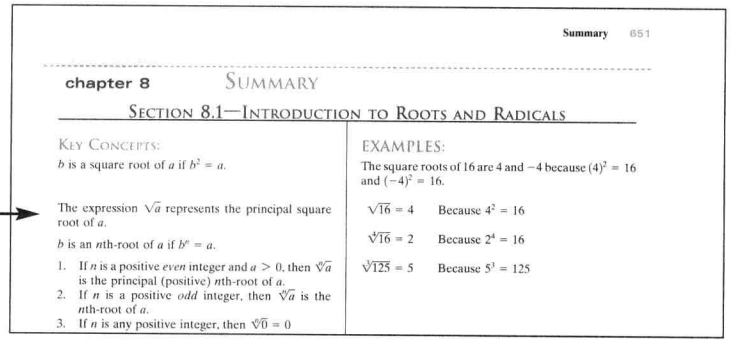
Midchapter Reviews

The Midchapter Reviews are provided to help you strengthen your understanding of concepts learned in the beginning of a chapter before you move on to new ideas presented later in the chapter.

End-of-Chapter Summary and Exercises

The **Summary**, found at the end of each chapter, outlines key concepts and terms for each section, and illustrates concepts with examples. With this list, you can quickly identify important ideas and vocabulary to be reviewed before quizzes or exams. Following the Summary is a set of **Review Exercises** that are organized by section. A **Chapter Test** appears after each set of Review Exercises.

Chapters 2–9 also include a **Cumulative Review** that follows the Chapter Test. These end-of-chapter materials are useful resources that will help you prepare for quizzes or exams.



Summary 651

chapter 8 SUMMARY

SECTION 8.1—INTRODUCTION TO ROOTS AND RADICALS

KEY CONCEPTS:

b is a square root of a if $b^2 = a$.

The expression $\sqrt{a}$ represents the principal square root of a.

b is an nth-root of a if $b^n = a$.

1. If n is a positive *even* integer and $a > 0$, then $\sqrt[n]{a}$ is the principal (positive) nth-root of a.
2. If n is a positive *odd* integer, then $\sqrt[n]{a}$ is the nth-root of a.
3. If n is any positive integer, then $\sqrt[n]{0} = 0$

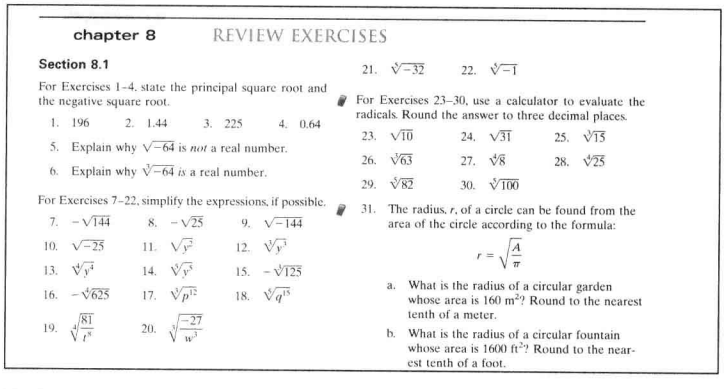
EXAMPLES:

The square roots of 16 are 4 and -4 because $(4)^2 = 16$ and $(-4)^2 = 16$.

$\sqrt{16} = 4$ Because $4^2 = 16$

$\sqrt[4]{16} = 2$ Because $2^4 = 16$

$\sqrt[3]{125} = 5$ Because $5^3 = 125$



chapter 8 REVIEW EXERCISES

Section 8.1

For Exercises 1–4, state the principal square root and the negative square root.

1. 196 2. 1.44 3. 225 4. 0.64
5. Explain why $\sqrt{-64}$ is *not* a real number.
6. Explain why $\sqrt[3]{-64}$ *is* a real number.

For Exercises 7–22, simplify the expressions, if possible.

7. $-\sqrt{144}$ 8. $-\sqrt{25}$ 9. $\sqrt{-144}$
10. $\sqrt{-25}$ 11. $\sqrt{y^2}$ 12. $\sqrt[3]{y^3}$
13. $\sqrt[4]{y^4}$ 14. $\sqrt[5]{y^5}$ 15. $-\sqrt[3]{125}$
16. $-\sqrt[4]{625}$ 17. $\sqrt[3]{p^{12}}$ 18. $\sqrt[5]{q^{15}}$
19. $\sqrt[4]{\frac{81}{t^8}}$ 20. $\sqrt[3]{\frac{-27}{w^3}}$
21. $\sqrt[5]{-32}$ 22. $\sqrt[3]{-1}$

For Exercises 23–30, use a calculator to evaluate the radicals. Round the answer to three decimal places.

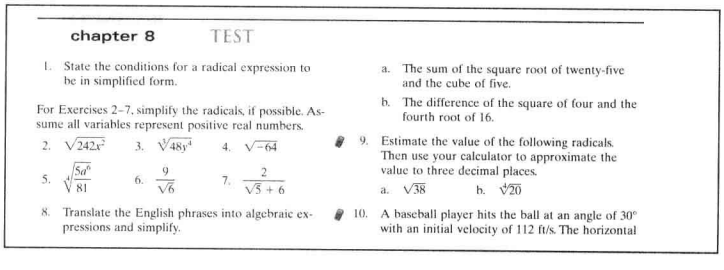
23. $\sqrt{10}$ 24. $\sqrt{31}$ 25. $\sqrt[3]{15}$
26. $\sqrt[3]{63}$ 27. $\sqrt[4]{8}$ 28. $\sqrt[4]{25}$
29. $\sqrt[4]{82}$ 30. $\sqrt[5]{100}$

31. The radius, r, of a circle can be found from the area of the circle according to the formula:

$$r = \sqrt{\frac{A}{\pi}}$$

a. What is the radius of a circular garden whose area is 160 m^2? Round to the nearest tenth of a meter.

b. What is the radius of a circular fountain whose area is 1600 ft^2? Round to the nearest tenth of a foot.

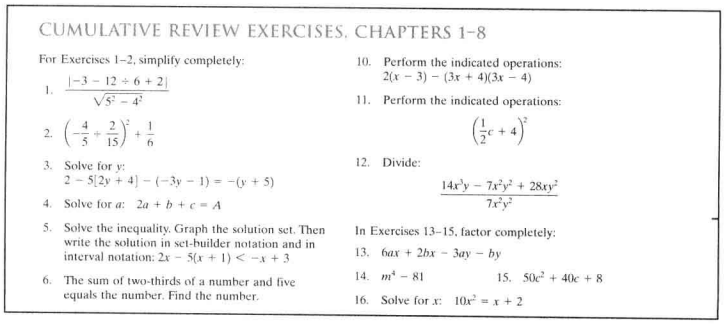


chapter 8 TEST

1. State the conditions for a radical expression to be in simplified form.

For Exercises 2–7, simplify the radicals, if possible. Assume all variables represent positive real numbers.

2. $\sqrt{242x^2}$ 3. $\sqrt[3]{48y^4}$ 4. $\sqrt{-64}$
5. $\sqrt[4]{\frac{5a^6}{81}}$ 6. $\frac{9}{\sqrt{6}}$ 7. $\frac{2}{\sqrt{5}+6}$
8. Translate the English phrases into algebraic expressions and simplify.
   a. The sum of the square root of twenty-five and the cube of five.
   b. The difference of the square of four and the fourth root of 16.
9. Estimate the value of the following radicals. Then use your calculator to approximate the value to three decimal places.
   a. $\sqrt{38}$ b. $\sqrt[3]{20}$
10. A baseball player hits the ball at an angle of 30° with an initial velocity of 112 ft/s. The horizontal



CUMULATIVE REVIEW EXERCISES, CHAPTERS 1–8

For Exercises 1–2, simplify completely:

1. $\frac{|-3 - 12 \div 6 + 2|}{\sqrt{5^2 - 4^2}}$
2. $\left(-\frac{4}{5} \div \frac{2}{15}\right)^2 + \frac{1}{6}$
3. Solve for y: $2 - 5[2y + 4] - (-3y - 1) = -(y + 5)$
4. Solve for a: $2a + b + c = A$
5. Solve the inequality. Graph the solution set. Then write the solution in set-builder notation and in interval notation: $2x - 5(x + 1) < -x + 3$
6. The sum of two-thirds of a number and five equals the number. Find the number.
10. Perform the indicated operations: $2(x - 3) - (3x + 4)(3x - 4)$
11. Perform the indicated operations: $\left(\frac{1}{2}c + 4\right)^2$
12. Divide: $\frac{14x^3y - 7x^2y^2 + 28xy^2}{7x^2y^2}$

In Exercises 13–15, factor completely:

13. $6ax + 2bx - 3ay - by$
14. $m^4 - 81$ 15. $50c^2 + 40c + 8$
16. Solve for x: $10x^2 = x + 2$

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