Simplifying Radical Expressions

Product Property of Square Roots  The Product Property of Square Roots and prime factorization can be used to simplify expressions involving irrational square roots. When you simplify radical expressions with variables, use absolute value to ensure nonnegative results.

| Product Property of Square Roots | For any numbers a and b, where a ≥ 0 and b ≥ 0, \( \sqrt{ab} = \sqrt{a} \cdot \sqrt{b} \). |

Example 1  Simplify \( \sqrt{180} \).

\[
\sqrt{180} = \sqrt{2 \cdot 2 \cdot 3 \cdot 3 \cdot 5} \quad \text{Prime factorization of 180}
\]
\[
= \sqrt{2^2 \cdot 3^2 \cdot 5} \quad \text{Product Property of Square Roots}
\]
\[
= 2 \cdot 3 \cdot \sqrt{5} \quad \text{Simplify.}
\]
\[
= 6\sqrt{5} \quad \text{Simplify.}
\]

Example 2  Simplify \( \sqrt{120a^2 \cdot b^5 \cdot c^4} \).

\[
\sqrt{120a^2 \cdot b^5 \cdot c^4} = \sqrt{2^3 \cdot 3 \cdot 5 \cdot a^2 \cdot b^5 \cdot c^4}
\]
\[
= \sqrt{2^2 \cdot 2 \cdot 3 \cdot 5} \cdot \sqrt{a^2} \cdot \sqrt{b^4} \cdot \sqrt{b} \cdot \sqrt{c^4}
\]
\[
= 2 \cdot \sqrt{2} \cdot \sqrt{3} \cdot \sqrt{5} \cdot |a| \cdot b^2 \cdot \sqrt{b} \cdot c^2
\]
\[
= 2|a|b^2c^2\sqrt{30b}
\]

Exercises

Simplify each expression.

1. \( \sqrt{28} \)  
2. \( \sqrt{68} \)  
3. \( \sqrt{60} \)  
4. \( \sqrt{75} \)

5. \( \sqrt{162} \)  
6. \( \sqrt{3 \cdot \sqrt{6}} \)  
7. \( \sqrt{2 \cdot \sqrt{5}} \)  
8. \( \sqrt{5 \cdot \sqrt{10}} \)

9. \( \sqrt{4a^2} \)  
10. \( \sqrt{9x^4} \)  
11. \( \sqrt{300a^4} \)  
12. \( \sqrt{128c^6} \)

13. \( 4\sqrt{10} \cdot 3\sqrt{6} \)  
14. \( \sqrt{3x^2} \cdot 3\sqrt{3x^4} \)  
15. \( \sqrt{20a^2b^4} \)  
16. \( \sqrt{100x^3y} \)

17. \( \sqrt{24a^4b^5} \)  
18. \( \sqrt{81x^4y^2} \)  
19. \( \sqrt{150a^2b^2c} \)

20. \( \sqrt{72a^6b^3c^2} \)  
21. \( \sqrt{45x^2y^5z^8} \)  
22. \( \sqrt{98x^4y^6z^2} \)
**10-2 Study Guide and Intervention (continued)**

**Simplifying Radical Expressions**

**Quotient Property of Square Roots** A fraction containing radicals is in simplest form if no radicals are left in the denominator. The *Quotient Property of Square Roots* and rationalizing the denominator can be used to simplify radical expressions that involve division. When you rationalize the denominator, you multiply the numerator and denominator by a radical expression that gives a rational number in the denominator.

| Quotient Property of Square Roots | For any numbers $a$ and $b$, where $a \geq 0$ and $b > 0$, $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$. |

**Example** Simplify $\sqrt{\frac{56}{45}}$.

\[
\sqrt{\frac{56}{45}} = \sqrt{\frac{4 \cdot 14}{9 \cdot 5}} = \frac{2 \cdot \sqrt{14}}{3 \cdot \sqrt{5}} = \frac{2\sqrt{14}}{3\sqrt{5}} \cdot \frac{\sqrt{5}}{\sqrt{5}} = \frac{2\sqrt{70}}{15}
\]

Simplify the numerator and denominator.

Multiply by $\frac{\sqrt{5}}{\sqrt{5}}$ to rationalize the denominator.

**Exercises**

Simplify each expression.

1. $\frac{\sqrt{9}}{\sqrt{18}}$

2. $\frac{\sqrt{8}}{\sqrt{24}}$

3. $\frac{\sqrt{100}}{\sqrt{121}}$

4. $\frac{\sqrt{75}}{\sqrt{3}}$

5. $\frac{8\sqrt{2}}{2\sqrt{8}}$

6. $\frac{\sqrt{\frac{2}{5}} \cdot \sqrt{\frac{6}{5}}}{\sqrt{\frac{2}{5}}}$

7. $\sqrt{\frac{3}{4}} \cdot \sqrt{\frac{5}{2}}$

8. $\sqrt{\frac{5}{7}} \cdot \sqrt{\frac{2}{5}}$

9. $\sqrt{\frac{3a^2}{10b^2}}$

10. $\sqrt{\frac{x^6}{y^4}}$

11. $\sqrt{\frac{100a^4}{144b^8}}$

12. $\sqrt{\frac{75b^3c^6}{a^2}}$

13. $\frac{\sqrt{4}}{3 - \sqrt{5}}$

14. $\frac{\sqrt{8}}{2 + \sqrt{3}}$

15. $\frac{\sqrt{5}}{5 + \sqrt{5}}$

16. $\frac{\sqrt{8}}{2\sqrt{7} + 4\sqrt{10}}$
1. **SPORTS** Jasmine calculated the height of her team’s soccer goal to be $\frac{15}{\sqrt{3}}$ feet. Simplify the expression.

2. **NATURE** In 2004, an earthquake below the ocean floor initiated a devastating tsunami in the Indian Ocean. Scientists can approximate the velocity (in feet per second) of a tsunami in water of depth $d$ (in feet) with the formula $V = \sqrt{16d}$. Determine the velocity of a tsunami in 300 feet of water. Write your answer in simplified radical form.

3. **AUTOMOBILES** The following formula can be used to find the “zero to sixty” time for a car, or the time it takes for a car to accelerate from a stop to sixty miles per hour.

   $$V = \sqrt{\frac{2PT}{M}}$$

   $V$ is the velocity (in meters per second). $P$ is the car’s average power (in watts). $M$ is the mass of the car (in kilograms). $T$ is the time (in seconds).

   Find the time it takes for a 900-kilogram car with an average 60,000 watts of power to accelerate from stop to 26.82 meters per second (60 miles per hour). Round your answer to the nearest hundredth.

4. **PHYSICAL SCIENCE** When a substance such as water vapor is in its gaseous state, the volume and the velocity of its molecules increase as temperature increases. The average velocity $V$ of a molecule with mass $m$ at temperature $T$ is given by the formula $V = \sqrt{\frac{3kT}{m}}$. Solve the equation for $k$.

5. **GEOMETRY** Suppose Emeryville Hospital wants to build a new helipad on which medic rescue helicopters can land. The helipad will be circular and made of fire resistant rubber.

   a. If the area of the helipad is $A$, write an equation for the radius $r$.

   b. Write an expression in simplified radical form for the radius of a helipad with an area of 288 square meters.

   c. Using your calculator, find a decimal approximation for the radius. Round your answer to the nearest tenth.
CONSUMABLE WORKBOOKS  Many of the worksheets contained in the Chapter Resource Masters booklets are available as consumable workbooks in both English and Spanish.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Guide and Intervention Workbook</td>
<td>0-07-890835-3</td>
<td>978-0-07-890835-4</td>
</tr>
<tr>
<td>Homework Practice Workbook</td>
<td>0-07-890836-1</td>
<td>978-0-07-890836-1</td>
</tr>
<tr>
<td>Homework Practice Workbook (Spanish)</td>
<td>0-07-890840-X</td>
<td>978-0-07-890840-8</td>
</tr>
</tbody>
</table>

ANSWERS FOR WORKBOOKS  The answers for Chapter 10 of these workbooks can be found in the back of this Chapter Resource Masters booklet.

StudentWorks Plus™  This CD-ROM includes the entire Student Edition text along with the English workbooks listed above.

TeacherWorks Plus™  All of the materials found in this booklet are included for viewing, printing, and editing in this CD-ROM.

These masters contain a Spanish version of Chapter 10 Test Form 2A and Form 2C.
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All of the materials found in this booklet are included for viewing and printing on the TeacherWorks Plus™ CD-ROM.

Chapter Resources

Student-Built Glossary (pages 1–2) These masters are a student study tool that presents up to twenty of the key vocabulary terms from the chapter. Students are to record definitions and/or examples for each term. You may suggest that students highlight or star the terms with which they are not familiar. Give this to students before beginning Lesson 10-1. Encourage them to add these pages to their mathematics study notebooks. Remind them to complete the appropriate words as they study each lesson.

Anticipation Guide (pages 3–4) This master, presented in both English and Spanish, is a survey used before beginning the chapter to pinpoint what students may or may not know about the concepts in the chapter. Students will revisit this survey after they complete the chapter to see if their perceptions have changed.

Lesson Resources

Study Guide and Intervention These masters provide vocabulary, key concepts, additional worked-out examples and Check Your Progress exercises to use as a reteaching activity. It can also be used in conjunction with the Student Edition as an instructional tool for students who have been absent.

Skills Practice This master focuses more on the computational nature of the lesson. Use as an additional practice option or as homework for second-day teaching of the lesson.

Practice This master closely follows the types of problems found in the Exercises section of the Student Edition and includes word problems. Use as an additional practice option or as homework for second-day teaching of the lesson.

Word Problem Practice This master includes additional practice in solving word problems that apply the concepts of the lesson. Use as an additional practice or as homework for second-day teaching of the lesson.

Enrichment These activities may extend the concepts of the lesson, offer an historical or multicultural look at the concepts, or widen students’ perspectives on the mathematics they are learning. They are written for use with all levels of students.

Graphing Calculator, TI-Nspire, or Spreadsheet Activities These activities present ways in which technology can be used with the concepts in some lessons of this chapter. Use as an alternative approach to some concepts or as an integral part of your lesson presentation.
Assessment Options

The assessment masters in the Chapter 10 Resource Masters offer a wide range of assessment tools for formative (monitoring) assessment and summative (final) assessment.

Student Recording Sheet This master corresponds with the standardized test practice at the end of the chapter.

Extended Response Rubric This master provides information for teachers and students on how to assess performance on open-ended questions.

Quizzes Four free-response quizzes offer assessment at appropriate intervals in the chapter.

Mid-Chapter Test This 1-page test provides an option to assess the first half of the chapter. It parallels the timing of the Mid-Chapter Quiz in the Student Edition and includes both multiple-choice and free-response questions.

Vocabulary Test This test is suitable for all students. It includes a list of vocabulary words and 11 questions to assess students' knowledge of those words. This can also be used in conjunction with one of the leveled chapter tests.

Leveled Chapter Tests

• Form 1 contains multiple-choice questions and is intended for use with below grade level students.

• Forms 2A and 2B contain multiple-choice questions aimed at on grade level students. These tests are similar in format to offer comparable testing situations.

• Forms 2C and 2D contain free-response questions aimed at on grade level students. These tests are similar in format to offer comparable testing situations.

• Form 3 is a free-response test for use with above grade level students.

All of the above mentioned tests include a free-response Bonus question.

Extended-Response Test Performance assessment tasks are suitable for all students. Samples answers and a scoring rubric are included for evaluation.

Standardized Test Practice These three pages are cumulative in nature. It includes three parts: multiple-choice questions with bubble-in answer format, griddable questions with answer grids, and short-answer free-response questions.

Answers

• The answers for the Anticipation Guide and Lesson Resources are provided as reduced pages with answers appearing in red.

• Full-size answer keys are provided for the assessment masters.
# 10 Student-Built Glossary

This is an alphabetical list of the key vocabulary terms you will learn in Chapter 10. As you study the chapter, complete each term’s definition or description. Remember to add the page number where you found the term. Add these pages to your Algebra Study Notebook to review vocabulary at the end of the chapter.

<table>
<thead>
<tr>
<th>Vocabulary Term</th>
<th>Found on Page</th>
<th>Definition/Description/Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>conjugate</td>
<td></td>
<td>KAHN • jih • guht</td>
</tr>
<tr>
<td>converse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cosine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance Formula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hypotenuse</td>
<td></td>
<td>hy • PAH • tn • oos</td>
</tr>
<tr>
<td>inverse cosine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>inverse sine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>inverse tangent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>legs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continued on the next page)
<table>
<thead>
<tr>
<th>Vocabulary Term</th>
<th>Found on Page</th>
<th>Definition/Description/Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>midpoint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midpoint Formula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>radical equations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>radical functions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>radicand</td>
<td>RA • duh • KAND</td>
<td></td>
</tr>
<tr>
<td>similar triangles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tangent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>trigonometry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 10 Anticipation Guide

### Radical Expressions and Triangles

**Step 1** Before you begin Chapter 10

- Read each statement.
- Decide whether you Agree (A) or Disagree (D) with the statement.
- Write A or D in the first column OR if you are not sure whether you agree or disagree, write NS (Not Sure).

<table>
<thead>
<tr>
<th>STEP 1 A, D, or NS</th>
<th>Statement</th>
<th>STEP 2 A or D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>An expression that contains a square root is called a radical expression.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>It is always true that $\sqrt{xy}$ will equal $\sqrt{x} \cdot \sqrt{y}$.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>$\frac{1}{\sqrt{3}}$ is in simplest form because $\sqrt{3}$ is not a whole number.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>The sum of $3\sqrt{3}$ and $2\sqrt{3}$ will equal $5\sqrt{3}$.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Before multiplying two radical expressions with different radicands the square roots must be evaluated.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>When solving radical equations by squaring each side of the equation, it is possible to obtain solutions that are not solutions to the original equation.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>The longest side of any triangle is called the hypotenuse.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Because $5^2 = 4^2 + 3^2$, a triangle whose sides have lengths 3, 4, and 5 will be a right triangle.</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>On a coordinate plane, the distance between any two points can be found using the Pythagorean Theorem.</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>The Distance Formula cannot be used to find the distance between two points on the same vertical line.</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Two triangles are similar only if their corresponding angles are congruent and the measures of their corresponding sides are in proportion.</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>All right triangles are similar.</td>
<td></td>
</tr>
</tbody>
</table>

### Step 2 After you complete Chapter 10

- Reread each statement and complete the last column by entering an A or a D.
- Did any of your opinions about the statements change from the first column?
- For those statements that you mark with a D, use a piece of paper to write an example of why you disagree.
# Ejercicios preparatorios

### Expresiones radicales y triángulos

#### Paso 1

**Antes de comenzar el Capítulo 10**

- Lee cada enunciado.
- Decide si estás de acuerdo (A) o en desacuerdo (D) con el enunciado.
- Escribe A o D en la primera columna O si no estás seguro(a) de la respuesta, escribe NS (No estoy seguro(a)).

<table>
<thead>
<tr>
<th>PASO 1 A, D o NS</th>
<th>Enunciado</th>
<th>PASO 2 A o D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Una expresión que contiene una raíz cuadrada se denomina expresión radical.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Siempre es verdadero que ( \sqrt{xy} ) será igual a ( \sqrt{x} \cdot \sqrt{y} ).</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>( \frac{1}{\sqrt{3}} ) está en forma reducida porque ( \sqrt{3} ) no es un número entero.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>La suma de ( 3\sqrt{3} ) y ( 2\sqrt{3} ) será igual a ( 5\sqrt{3} ).</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Antes de multiplicar dos expresiones radicales con radicandos diferentes, se debe evaluar las raíces cuadradas.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Cuando se resuelven ecuaciones radicales mediante la elevación al cuadrado de cada lado de la ecuación, es posible obtener soluciones que no son soluciones para la ecuación original.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>El lado más largo de cualquier triángulo se llama hipotenusa.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Debido a que ( 5^2 = 4^2 + 3^2 ), un triángulo cuyos lados tienen longitudes 3, 4 y 5 será un triángulo rectángulo.</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>En el plano de coordenadas, la distancia entre cualesquiera dos puntos se puede encontrar usando el teorema de Pitágoras.</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>No se puede usar la fórmula de la distancia para calcular la distancia entre dos puntos en la misma recta vertical.</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Dos triángulos son semejantes solo si sus ángulos correspondientes son congruentes y las medidas de sus lados correspondientes están en proporción.</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Todos los triángulos rectángulos son semejantes.</td>
<td></td>
</tr>
</tbody>
</table>

#### Paso 2

**Después de completar el Capítulo 10**

- Vuelve a leer cada enunciado y completa la última columna con una A o una D.
- ¿Cambió cualquiera de tus opiniones sobre los enunciados de la primera columna?
- En una hoja de papel aparte, escribe un ejemplo de por qué estás en desacuerdo con los enunciados que marcaste con una D.
Dilations of Radical Functions  A square root function contains the square root of a variable. Square root functions are a type of radical function.

In order for a square root to be a real number, the radicand, or the expression under the radical sign, cannot be negative. Values that make the radicant negative are not included in the domain.

\[
\text{Square Root Function} \quad f(x) = \sqrt{x}
\]

**Parent function:** \( f(x) = \sqrt{x} \)

**Type of graph:** curve

**Domain:** \( \{x | x \geq 0\} \)

**Range:** \( \{y | y \geq 0\} \)

**Example**

Graph \( y = 3\sqrt{x} \). State the domain and range.

**Step 1** Make a table. Choose nonnegative values for \( x \).

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.5</td>
<td>( \approx 2.12 )</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>( \approx 4.24 )</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>( \approx 7.35 )</td>
</tr>
</tbody>
</table>

**Step 2** Plot points and draw a smooth curve.

The domain is \( \{x | x \geq 0\} \) and the range is \( \{y | y \geq 0\} \).

**Exercises**

Graph each function, and compare to the parent graph. State the domain and range.

1. \( y = \frac{3}{2}\sqrt{x} \)
2. \( y = 4\sqrt{x} \)
3. \( y = \frac{5}{2}\sqrt{x} \)
Reflections and Translations of Radical Functions Radical functions, like quadratic functions, can be translated horizontally and vertically, as well as reflected across the x-axis. To draw the graph of \( y = a \sqrt{x} + h \), follow these steps.

<table>
<thead>
<tr>
<th>( y ) = ( a \sqrt{x} + h )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> Draw the graph of ( y = +c \sqrt{x} ). The graph starts at the origin and passes through the point at ((1, a)). If ( a &gt; 0 ), the graph is in the 1st quadrant. If ( a &lt; 0 ), the graph is reflected across the x-axis and is in the 4th quadrant.</td>
</tr>
<tr>
<td><strong>Step 2</strong> Translate the graph (</td>
</tr>
<tr>
<td><strong>Step 3</strong> Translate the graph (</td>
</tr>
</tbody>
</table>

**Example** Graph \( y = -\sqrt{x} + 1 \) and compare to the parent graph. State the domain and range.

**Step 1** Make a table of values.

<table>
<thead>
<tr>
<th>( x )</th>
<th>( -1 )</th>
<th>( 0 )</th>
<th>( 1 )</th>
<th>( 3 )</th>
<th>( 8 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>( 0 )</td>
<td>( -1 )</td>
<td>(-1.41)</td>
<td>(-2)</td>
<td>(-3)</td>
</tr>
</tbody>
</table>

**Step 2** This is a horizontal translation 1 unit to the left of the parent function and reflected across the x-axis. The domain is \( \{x | x \geq 0\} \) and the range is \( \{y | y \leq 0\} \).

**Exercises**

Graph each function, and compare to the parent graph. State the domain and range.

1. \( y = \sqrt{x} + 3 \)  
2. \( y = \sqrt{x} - 1 \)  
3. \( y = -\sqrt{x} - 1 \)
10-1 Skills Practice

Square Root Functions

Graph each function, and compare to the parent graph. State the domain and range.

1. \( y = 2 \sqrt{x} \)

2. \( y = \frac{1}{2} \sqrt{x} \)

3. \( y = 5 \sqrt{x} \)

4. \( y = \sqrt{x} + 1 \)

5. \( y = \sqrt{x} - 4 \)

6. \( y = \sqrt{x - 1} \)

7. \( y = -\sqrt{x - 3} \)

8. \( y = \sqrt{x - 2} + 3 \)

9. \( y = -\frac{1}{2} \sqrt{x - 4} + 1 \)
10-1 Practice

Square Root Functions

Graph each function, and compare to the parent graph. State the domain and range.

1. \( y = \frac{4}{3} \sqrt{x} \)
2. \( y = \sqrt{x} + 2 \)
3. \( y = \sqrt{x - 3} \)

4. \( y = -\sqrt{x} + 1 \)
5. \( y = 2 \sqrt{x - 1} + 1 \)
6. \( y = -\sqrt{x - 2} + 2 \)

7. **OHM’S LAW** In electrical engineering, the resistance of a circuit can be found by the equation \( I = \sqrt{\frac{P}{R}} \), where \( I \) is the current in amperes, \( P \) is the power in watts, and \( R \) is the resistance of the circuit in ohms. Graph this function for a circuit with a resistance of 4 ohms.
10-1 Word Problem Practice

Square Root Functions

1. **PENDULUM MOTION** The period $T$ of a pendulum in seconds, which is the time for the pendulum to return to the point of release, is given by the equation $T = 1.11\sqrt{L}$. The length of the pendulum in feet is given by $L$. Graph this function.

2. **EMPIRE STATE BUILDING** The roof of the Empire State Building is 1250 feet above the ground. The velocity of an object dropped from a height of $h$ meters is given by the function $V = \sqrt{2gh}$, where $g$ is the gravitational constant, 32.2 feet per second squared. If an object is dropped from the roof of the building, how fast is it traveling when it hits the street below?

3. **ERROR ANALYSIS** Gregory is drawing the graph of $y = -5\sqrt{x} + 1$. He describes the range and domain as $\{x \mid x \geq -1\}$, $\{y \mid y \geq 0\}$. Explain and correct the mistake that Gregory made.

4. **CAPACITORS** A capacitor is a set of plates that can store energy in an electric field. The voltage $V$ required to store $E$ joules of energy in a capacitor with a capacitance of $C$ farads is given by $V = \sqrt{\frac{2E}{C}}$.

   a. Rewrite and simplify the equation for the case of a 0.0002 farad capacitor.

   b. Graph the equation you found in part a.

   c. How would the graph differ if you wished to store $E + 1$ joules of energy in the capacitor instead?

   d. How would the graph differ if you applied a voltage of $V + 1$ volts instead?
**10-1 Enrichment**

**Cubic Root Functions**

A **cubic root function** contains the cubic root of a variable. The **cubic root** of a number \( x \) are the numbers \( y \) that satisfy the equation \( y \cdot y \cdot y = x \) (or, alternatively, \( y = \sqrt[3]{x} \)). Unlike square root functions, cubic root functions return real numbers when the radicand is negative.

**Example**  
Graph \( y = \sqrt[3]{x} \).

**Step 1** Make a table.

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>−5</td>
<td>−1.71</td>
</tr>
<tr>
<td>−3</td>
<td>−1.44</td>
</tr>
<tr>
<td>−1</td>
<td>−1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1.44</td>
</tr>
<tr>
<td>5</td>
<td>1.71</td>
</tr>
</tbody>
</table>

**Step 2** Plot points and draw a smooth curve.

**Exercises**

Graph each function, and compare to the parent graph.

1. \( y = 2 \sqrt[3]{x} \)

2. \( y = \sqrt[3]{x} + 1 \)

3. \( y = \sqrt[3]{x} + 1 \)

4. \( y = \sqrt[3]{x − 1} + 2 \)

5. \( y = 3 \sqrt[3]{x − 2} \)

6. \( y = −\sqrt[3]{x} + 3 \)
10-2 Skills Practice

Simplifying Radical Expressions

Simplify each expression.

1. \( \sqrt{28} \)
2. \( \sqrt{40} \)

3. \( \sqrt{72} \)
4. \( \sqrt{99} \)

5. \( \sqrt{2} \cdot \sqrt{10} \)
6. \( \sqrt{5} \cdot \sqrt{60} \)

7. \( 3\sqrt{5} \cdot \sqrt{5} \)
8. \( \sqrt{6} \cdot 4\sqrt{24} \)

9. \( 2\sqrt{3} \cdot 3\sqrt{15} \)
10. \( \sqrt{16b^4} \)

11. \( \sqrt{81a^2d^4} \)
12. \( \sqrt{40x^4y^6} \)

13. \( \sqrt{75m^5p^2} \)
14. \( \sqrt{\frac{5}{3}} \)

15. \( \sqrt{\frac{1}{6}} \)
16. \( \sqrt{\frac{6}{7}} \cdot \sqrt{\frac{1}{3}} \)

17. \( \sqrt{\frac{q}{12}} \)
18. \( \sqrt{\frac{4h}{5}} \)

19. \( \sqrt{\frac{12}{b^2}} \)
20. \( \sqrt{\frac{45}{4m^4}} \)

21. \( \frac{2}{4 + \sqrt{5}} \)
22. \( \frac{3}{2 - \sqrt{3}} \)

23. \( \frac{5}{7 + \sqrt{7}} \)
24. \( \frac{4}{3 - \sqrt{2}} \)
Simplify.

1. \(\sqrt{24}\)  
2. \(\sqrt{60}\)  
3. \(\sqrt{108}\)  
4. \(\sqrt{8} \cdot \sqrt{6}\)  
5. \(\sqrt{7} \cdot \sqrt{14}\)  
6. \(3\sqrt{12} \cdot 5\sqrt{6}\)  
7. \(4\sqrt{3} \cdot 3\sqrt{18}\)  
8. \(\sqrt{27tu^3}\)  
9. \(\sqrt{50p^5}\)  
10. \(\sqrt{108x^6y^4z^5}\)  
11. \(\sqrt{56m^2n^4p^5}\)  
12. \(\frac{\sqrt{8}}{\sqrt{6}}\)  
13. \(\sqrt{\frac{2}{10}}\)  
14. \(\sqrt{\frac{5}{32}}\)  
15. \(\sqrt{\frac{3}{4} \cdot \sqrt{\frac{4}{5}}\)}  
16. \(\sqrt{\frac{1}{7} \cdot \sqrt{\frac{7}{11}})}\)  
17. \(\sqrt{\frac{3k}{\sqrt{8}}\)}\)  
18. \(\sqrt{\frac{18}{x^3}}\)  
19. \(\sqrt{\frac{4y}{3y^2}}\)  
20. \(\sqrt{\frac{9ab}{4ab^2}}\)\)  
21. \(\frac{3}{5 - \sqrt{2}}\)  
22. \(\frac{8}{3 + \sqrt{3}}\)  
23. \(\frac{5}{\sqrt{7} + \sqrt{3}}\)  
24. \(\frac{3\sqrt{7}}{-1 - \sqrt{27}}\)\)

25. **SKY DIVING** When a skydiver jumps from an airplane, the time \(t\) it takes to free fall a given distance can be estimated by the formula \(t = \sqrt{\frac{2s}{9.8}}\), where \(t\) is in seconds and \(s\) is in meters. If Julie jumps from an airplane, how long will it take her to free fall 750 meters?

26. **METEOROLOGY** To estimate how long a thunderstorm will last, meteorologists can use the formula \(t = \sqrt{\frac{d^3}{216}}\), where \(t\) is the time in hours and \(d\) is the diameter of the storm in miles.
   
a. A thunderstorm is 8 miles in diameter. Estimate how long the storm will last. Give your answer in simplified form and as a decimal.
   
b. Will a thunderstorm twice this diameter last twice as long? Explain.
**Squares and Square Roots From a Graph**

The graph of \( y = x^2 \) can be used to find the squares and square roots of numbers.

To find the square of 3, locate 3 on the \( x \)-axis. Then find its corresponding value on the \( y \)-axis. The arrows show that \( 3^2 = 9 \).

To find the square root of 4, first locate 4 on the \( y \)-axis. Then find its corresponding value on the \( x \)-axis. Following the arrows on the graph, you can see that \( \sqrt{4} = 2 \).

A small part of the graph at \( y = x^2 \) is shown below. A 1:10 ratio for unit length on the \( y \)-axis to unit length on the \( x \)-axis is used.

**Example**

Find \( \sqrt{11} \).

The arrows show that \( \sqrt{11} = 3.3 \) to the nearest tenth.

**Exercises**

Use the graph above to find each of the following to the nearest whole number.

1. \( 1.5^2 \)  
2. \( 2.7^2 \)  
3. \( 0.9^2 \)  
4. \( 3.6^2 \)  
5. \( 4.2^2 \)  
6. \( 3.9^2 \)

Use the graph above to find each of the following to the nearest tenth.

7. \( \sqrt{15} \)  
8. \( \sqrt{8} \)  
9. \( \sqrt{3} \)  
10. \( \sqrt{5} \)  
11. \( \sqrt{14} \)  
12. \( \sqrt{17} \)
10-3 Study Guide and Intervention

Operations with Radical Expressions

Add or Subtract Radical Expressions When adding or subtracting radical expressions, use the Associative and Distributive Properties to simplify the expressions. If radical expressions are not in simplest form, simplify them.

Example 1 Simplify \(10\sqrt{6} - 5\sqrt{3} + 6\sqrt{3} - 4\sqrt{6}\).

\[
10\sqrt{6} - 5\sqrt{3} + 6\sqrt{3} - 4\sqrt{6} = (10 - 4)\sqrt{6} + (-5 + 6)\sqrt{3} \\
= 6\sqrt{6} + \sqrt{3}
\]

Example 2 Simplify \(3\sqrt{12} + 5\sqrt{75}\).

\[
3\sqrt{12} + 5\sqrt{75} = 3\sqrt{2^2 \cdot 3} + 5\sqrt{5^2 \cdot 3} \\
= 3 \cdot 2\sqrt{3} + 5 \cdot 5\sqrt{3} \\
= 6\sqrt{3} + 25\sqrt{3} \\
= 31\sqrt{3}
\]

Exercises

Simplify each expression.

1. \(2\sqrt{5} + 4\sqrt{5}\)  
2. \(\sqrt{6} - 4\sqrt{6}\)

3. \(\sqrt{8} - \sqrt{2}\)  
4. \(3\sqrt{75} + 2\sqrt{5}\)

5. \(\sqrt{20} + 2\sqrt{5} - 3\sqrt{5}\)  
6. \(2\sqrt{3} + \sqrt{6} - 5\sqrt{3}\)

7. \(\sqrt{12} + 2\sqrt{3} - 5\sqrt{3}\)  
8. \(3\sqrt{6} + 3\sqrt{2} - \sqrt{50} + \sqrt{24}\)

9. \(\sqrt{8a} - \sqrt{2a} + 5\sqrt{2a}\)  
10. \(\sqrt{54} + \sqrt{24}\)

11. \(\sqrt{3} + \sqrt{\frac{1}{3}}\)  
12. \(\sqrt{12} + \sqrt{\frac{1}{3}}\)

13. \(\sqrt{54} - \sqrt{\frac{1}{6}}\)  
14. \(\sqrt{80} - \sqrt{20} + \sqrt{180}\)

15. \(\sqrt{50} + \sqrt{18} - \sqrt{75} + \sqrt{27}\)  
16. \(2\sqrt{3} - 4\sqrt{45} + 2\sqrt{\frac{1}{3}}\)

17. \(\sqrt{125} - 2\sqrt{\frac{1}{5}} + \sqrt{\frac{1}{3}}\)  
18. \(\sqrt{\frac{2}{3}} + 3\sqrt{3} - 4\sqrt{\frac{1}{12}}\)
10-3 Study Guide and Intervention (continued)

Operations with Radical Expressions

Multiply Radical Expressions

Multiplying two radical expressions with different radicands is similar to multiplying binomials.

Example

Multiply \((3\sqrt{2} - 2\sqrt{5})(4\sqrt{20} + \sqrt{8})\).

Use the FOIL method.

\[
(3\sqrt{2} - 2\sqrt{5})(4\sqrt{20} + \sqrt{8}) = (3\sqrt{2})(4\sqrt{20}) + (3\sqrt{2})(\sqrt{8}) + (-2\sqrt{5})(4\sqrt{20}) + (-2\sqrt{5})(\sqrt{8})
\]

\[
= 12\sqrt{40} + 3\sqrt{16} - 8\sqrt{100} - 2\sqrt{40} \quad \text{Multiply.}
\]

\[
= 12\sqrt{2^2 \cdot 10} + 3 \cdot 4 - 8 \cdot 10 - 2\sqrt{2^2 \cdot 10} \quad \text{Simplify.}
\]

\[
= 24\sqrt{10} + 12 - 80 - 4\sqrt{10} \quad \text{Simplify.}
\]

\[
= 20\sqrt{10} - 68 \quad \text{Combine like terms.}
\]

Exercises

Simplify each expression.

1. \(2(\sqrt{3} + 4\sqrt{5})\)

2. \(\sqrt{6}(\sqrt{3} - 2\sqrt{6})\)

3. \(\sqrt{5}(\sqrt{5} - \sqrt{2})\)

4. \(\sqrt{2}(3\sqrt{7} + 2\sqrt{5})\)

5. \((2 - 4\sqrt{2})(2 + 4\sqrt{2})\)

6. \((3 + \sqrt{6})^2\)

7. \((2 - 2\sqrt{5})^2\)

8. \(3\sqrt{2}(\sqrt{8} + \sqrt{24})\)

9. \(\sqrt{8}(\sqrt{2} + 5\sqrt{8})\)

10. \((\sqrt{5} - 3\sqrt{2})(\sqrt{5} + 3\sqrt{2})\)

11. \((\sqrt{3} + \sqrt{6})^2\)

12. \((\sqrt{2} - 2\sqrt{3})^2\)

13. \((\sqrt{5} - \sqrt{2})(\sqrt{2} + \sqrt{6})\)

14. \((\sqrt{8} - \sqrt{2})(\sqrt{3} + \sqrt{6})\)

15. \((\sqrt{5} - \sqrt{18})(\sqrt{5} + \sqrt{3})\)

16. \((2\sqrt{3} - \sqrt{45})(\sqrt{12} + 2\sqrt{6})\)

17. \((2\sqrt{5} - 2\sqrt{3})(\sqrt{10} + \sqrt{6})\)

18. \((\sqrt{2} + 3\sqrt{3})(\sqrt{12} - 4\sqrt{8})\)
10-3 Skills Practice

Operations with Radical Expressions

Simplify each expression.

1. \(7\sqrt{7} - 2\sqrt{7}\)

2. \(3\sqrt{13} + 7\sqrt{13}\)

3. \(6\sqrt{5} - 2\sqrt{5} + 8\sqrt{5}\)

4. \(\sqrt{15} + 8\sqrt{15} - 12\sqrt{15}\)

5. \(12\sqrt{r} - 9\sqrt{r}\)

6. \(9\sqrt{6a} - 11\sqrt{6a} + 4\sqrt{6a}\)

7. \(\sqrt{44} - \sqrt{11}\)

8. \(\sqrt{28} + \sqrt{63}\)

9. \(4\sqrt{3} + 2\sqrt{12}\)

10. \(8\sqrt{54} - 4\sqrt{6}\)

11. \(\sqrt{27} + \sqrt{48} + \sqrt{12}\)

12. \(\sqrt{72} + \sqrt{50} - \sqrt{8}\)

13. \(\sqrt{180} - 5\sqrt{5} + \sqrt{20}\)

14. \(2\sqrt{24} + 4\sqrt{54} + 5\sqrt{96}\)

15. \(5\sqrt{8} + 2\sqrt{20} - \sqrt{8}\)

16. \(2\sqrt{13} + 4\sqrt{2} - 5\sqrt{13} + \sqrt{2}\)

17. \(\sqrt{2}(\sqrt{8} + \sqrt{6})\)

18. \(\sqrt{5}(\sqrt{10} - \sqrt{3})\)

19. \(\sqrt{6}(3\sqrt{2} - 2\sqrt{3})\)

20. \(3\sqrt{3}(2\sqrt{6} + 4\sqrt{10})\)

21. \((4 + \sqrt{3})(4 - \sqrt{3})\)

22. \((2 - \sqrt{6})^2\)

23. \((\sqrt{8} + \sqrt{2})(\sqrt{5} + \sqrt{3})\)

24. \((\sqrt{6} + 4\sqrt{5})(4\sqrt{3} - \sqrt{10})\)
10-3 Practice

Operations with Radical Expressions

Simplify each expression.

1. \(8\sqrt{30} - 4\sqrt{30}\)

2. \(2\sqrt{5} - 7\sqrt{5} - 5\sqrt{5}\)

3. \(7\sqrt{13x} - 14\sqrt{13x} + 2\sqrt{13x}\)

4. \(2\sqrt{45} + 4\sqrt{20}\)

5. \(\sqrt{40} - \sqrt{10} + \sqrt{90}\)

6. \(2\sqrt{32} + 3\sqrt{50} - 3\sqrt{18}\)

7. \(\sqrt{27} + \sqrt{18} + \sqrt{300}\)

8. \(5\sqrt{8} + 3\sqrt{20} - \sqrt{32}\)

9. \(\sqrt{14} - \sqrt{\frac{2}{7}}\)

10. \(\sqrt{50} + \sqrt{32} - \sqrt{\frac{1}{2}}\)

11. \(5\sqrt{19} + 4\sqrt{28} - 8\sqrt{19} + \sqrt{63}\)

12. \(3\sqrt{10} + \sqrt{75} - 2\sqrt{40} - 4\sqrt{12}\)

13. \(\sqrt{6}(\sqrt{10} + \sqrt{15})\)

14. \(\sqrt{5}(5\sqrt{2} - 4\sqrt{8})\)

15. \(2\sqrt{7}(3\sqrt{12} + 5\sqrt{8})\)

16. \((5 - \sqrt{15})^2\)

17. \((\sqrt{10} + \sqrt{6})(\sqrt{30} - \sqrt{18})\)

18. \((\sqrt{8} + \sqrt{12})(\sqrt{48} + \sqrt{18})\)

19. \((\sqrt{2} + 2\sqrt{8})(3\sqrt{6} - \sqrt{5})\)

20. \((4\sqrt{3} - 2\sqrt{5})(3\sqrt{10} + 5\sqrt{6})\)

21. SOUND The speed of sound \(V\) in meters per second near Earth’s surface is given by

\[V = 20\sqrt{t + 273},\]

where \(t\) is the surface temperature in degrees Celsius.

a. What is the speed of sound near Earth’s surface at 15°C and at 2°C in simplest form?

b. How much faster is the speed of sound at 15°C than at 2°C?

22. GEOMETRY A rectangle is \(5\sqrt{7} + 2\sqrt{3}\) meters long and \(6\sqrt{7} - 3\sqrt{3}\) meters wide.

a. Find the perimeter of the rectangle in simplest form.

b. Find the area of the rectangle in simplest form.
1. **ARCHITECTURE** The Pentagon is the building that houses the U.S. Department of Defense. Find the approximate perimeter of the building, which is a regular pentagon. Leave your answer as a radical expression.

![Pentagon Diagram]

2. **EARTH** The surface area of a sphere with radius \( r \) is given by the formula \( 4\pi r^2 \). Assuming that Earth is close to spherical in shape and has a surface area of about \( 5.1 \times 10^8 \) square kilometers, what is the radius of Earth to the nearest ten kilometers?

3. **GEOMETRY** The area of a trapezoid is found by multiplying its height by the average length of its bases. Find the area of deck attached to Mr. Wilson’s house. Give your answer as a simplified radical expression.

![Trapezoid Diagram]

4. **RECREATION** Carmen surveyed a ski slope using a digital device connected to a computer. The computer model assigned coordinates to the top and bottom points of the hill as shown in the diagram. Write a simplified radical expression that represents the slope of the hill.

![Ski Slope Diagram]

5. **FREE FALL** Suppose a ball is dropped from a building window 800 feet in the air. Another ball is dropped from a lower window 288 feet high. Both balls are released at the same time. Assume air resistance is not a factor and use the following formula to find how many seconds \( t \) it will take a ball to fall \( h \) feet.

\[
t = \frac{1}{4} \sqrt{h}
\]

a. How much time will pass between when the first ball hits the ground and when the second ball hits the ground? Give your answer as a simplified radical expression.

b. Which ball lands first?

c. Find a decimal approximation of the answer for part a. Round your answer to the nearest tenth.
The Wheel of Theodorus

The Greek mathematicians were intrigued by problems of representing different numbers and expressions using geometric constructions.

Theodorus, a Greek philosopher who lived about 425 B.C., is said to have discovered a way to construct the sequence $\sqrt{1}, \sqrt{2}, \sqrt{3}, \sqrt{4}, \ldots$.

The beginning of his construction is shown. You start with an isosceles right triangle with sides 1 unit long.

Use the figure above. Write each length as a radical expression in simplest form.

1. line segment $AO$
2. line segment $BO$
3. line segment $CO$
4. line segment $DO$
5. Describe how each new triangle is added to the figure.

6. The length of the hypotenuse of the first triangle is $\sqrt{2}$. For the second triangle, the length is $\sqrt{3}$. Write an expression for the length of the hypotenuse of the $n$th triangle.

7. Show that the method of construction will always produce the next number in the sequence. (Hint: Find an expression for the hypotenuse of the $(n + 1)$th triangle.)

8. In the space below, construct a Wheel of Theodorus. Start with a line segment 1 centimeter long. When does the Wheel start to overlap?
Radical Equations

Equations containing radicals with variables in the radicand are called **radical equations**. These can be solved by first using the following steps.

**Step 1** Isolate the radical on one side of the equation.
**Step 2** Square each side of the equation to eliminate the radical.

**Example 1**

Solve \(16 = \frac{\sqrt{x}}{2}\) for \(x\).

1. \(2(16) = 2\left(\frac{\sqrt{x}}{2}\right)\) Multiply each side by 2.
2. \(32 = \sqrt{x}\) Simplify.
3. \((32)^2 = (\sqrt{x})^2\) Square each side.
4. \(1024 = x\) Simplify.

The solution is 1024, which checks in the original equation.

**Example 2**

Solve \(\sqrt{4x - 7} + 2 = 7\).

1. \(\sqrt{4x - 7} + 2 = 7\) Original equation
2. \(\sqrt{4x - 7} + 2 - 2 = 7 - 2\) Subtract 2 from each side.
3. \(\sqrt{4x - 7} = 5\) Simplify.
4. \((\sqrt{4x - 7})^2 = 5^2\) Square each side.
5. \(4x - 7 = 25\) Simplify.
6. \(4x - 7 + 7 = 25 + 7\) Add 7 to each side.
7. \(4x = 32\) Simplify.
8. \(x = 8\) Divide each side by 4.

The solution is 8, which checks in the original equation.

**Exercises**

Solve each equation. Check your solution.

1. \(\sqrt{a} = 8\)
2. \(\sqrt{a} + 6 = 32\)
3. \(2\sqrt{x} = 8\)

4. \(7 = \sqrt{26 - n}\)
5. \(\sqrt{-a} = 6\)
6. \(\sqrt{3r^2} = 3\)

7. \(2\sqrt{3} = \sqrt{y}\)
8. \(2\sqrt{3a} - 2 = 7\)
9. \(\sqrt{x} - 4 = 6\)

10. \(\sqrt{2m + 3} = 5\)
11. \(\sqrt{3b - 2} + 19 = 24\)
12. \(\sqrt{4x - 1} = 3\)

13. \(\sqrt{3r + 2} = 2\sqrt{3}\)
14. \(\sqrt{\frac{x}{2}} = \frac{1}{2}\)
15. \(\sqrt{\frac{x}{8}} = 4\)

16. \(\sqrt{6x^2 + 5x} = 2\)
17. \(\sqrt{\frac{x}{3}} + 6 = 8\)
18. \(2\sqrt{\frac{3x}{5}} + 3 = 11\)
10-4 Study Guide and Intervention (continued)

Radical Equations

Extraneous Solutions To solve a radical equation with a variable on both sides, you need to square each side of the equation. Squaring each side of an equation sometimes produces extraneous solutions, or solutions that are not solutions of the original equation. Therefore, it is very important that you check each solution.

Example 1 Solve \( \sqrt{x + 3} = x - 3 \).

\[
\sqrt{x + 3} = x - 3 \\
(\sqrt{x + 3})^2 = (x - 3)^2 \\
x + 3 = x^2 - 6x + 9 \\
0 = x^2 - 7x + 6 \\
0 = (x - 1)(x - 6) \\
x - 1 = 0 \text{ or } x - 6 = 0 \\
x = 1 \text{ or } x = 6
\]

CHECK

\[
\sqrt{1 + 3} = 2 \\
\sqrt{1 + 3} = \sqrt{4} = 2 \\
6 + 3 = 9 \\
6 + 3 = 9 \\
2 = -2 \\
3 = 3
\]

Since \( x = 1 \) does not satisfy the original equation, \( x = 6 \) is the only solution.

Exercises

Solve each equation. Check your solution.

1. \( \sqrt{a} = a \)
2. \( \sqrt{a} + 6 = a \)
3. \( 2\sqrt{x} = x \)
4. \( n = \sqrt{2 - n} \)
5. \( \sqrt{-a} = a \)
6. \( \sqrt{10 - 6k} + 3 = k \)
7. \( \sqrt{y - 1} = y - 1 \)
8. \( \sqrt{3a - 2} = a \)
9. \( \sqrt{x + 2} = x \)
10. \( \sqrt{2b + 5} = b - 5 \)
11. \( \sqrt{3b + 6} = b + 2 \)
12. \( \sqrt{4x - 4} = x \)
13. \( r + \sqrt{2 - r} = 2 \)
14. \( \sqrt{x^2 + 10x} = x + 4 \)
15. \( -2\sqrt{\frac{x}{8}} = 15 \)
16. \( \sqrt{6x^2 - 4x} = x + 2 \)
17. \( \sqrt{2y^2 - 64} = y \)
18. \( \sqrt{3x^2 + 12x + 1} = x + 5 \)
Solve each equation. Check your solution.

1. \( \sqrt{f} = 7 \)  
2. \( \sqrt{-x} = 5 \)

3. \( \sqrt{5p} = 10 \)  
4. \( \sqrt{4y} = 6 \)

5. \( 2\sqrt{2} = \sqrt{u} \)  
6. \( 3\sqrt{5} = \sqrt{-u} \)

7. \( \sqrt{g} - 6 = 3 \)  
8. \( \sqrt{5a} + 2 = 0 \)

9. \( \sqrt{2t - 1} = 5 \)  
10. \( \sqrt{3k - 2} = 4 \)

11. \( \sqrt{x + 4} - 2 = 1 \)  
12. \( \sqrt{4x - 4} - 4 = 0 \)

13. \( \frac{\sqrt{d}}{3} = 4 \)  
14. \( \sqrt{\frac{m}{3}} = 3 \)

15. \( x = \sqrt{x + 2} \)  
16. \( d = \sqrt{12 - d} \)

17. \( \sqrt{6x - 9} = x \)  
18. \( \sqrt{6p - 8} = p \)

19. \( \sqrt{x + 5} = x - 1 \)  
20. \( \sqrt{8 - d} = d - 8 \)

21. \( \sqrt{r - 3} + 5 = r \)  
22. \( \sqrt{y - 1} + 3 = y \)

23. \( \sqrt{5n + 4} = n + 2 \)  
24. \( \sqrt{3z - 6} = z - 2 \)
**10-4 Practice**

**Radical Equations**

Solve each equation. Check your solution.

1. $\sqrt{-b} = 8$
2. $4\sqrt{3} = \sqrt{x}$
3. $2\sqrt{4r} + 3 = 11$
4. $6 - \sqrt{2y} = -2$
5. $\sqrt{k + 2} - 3 = 7$
6. $\sqrt{m - 5} = 4\sqrt{3}$
7. $\sqrt{6t + 12} = 8\sqrt{6}$
8. $\sqrt{3j - 11} + 2 = 9$
9. $\sqrt{2x + 15} + 5 = 18$
10. $\sqrt{3d} - 4 = 2$
11. $6\sqrt{\frac{3x}{3}} - 3 = 0$
12. $6 + \sqrt{\frac{5r}{6}} = -2$
13. $y = \sqrt{y + 6}$
14. $\sqrt{15 - 2x} = x$
15. $\sqrt{w + 4} = w + 4$
16. $\sqrt{17 - k} = k - 5$
17. $\sqrt{5m - 16} = m - 2$
18. $\sqrt{24 + 8q} = q + 3$
19. $\sqrt{4t + 17} - t - 3 = 0$
20. $4 - \sqrt{3m + 28} = m$
21. $\sqrt{10p + 61} - 7 = p$
22. $\sqrt{2x^2 - 9} = x$

**23. ELECTRICITY** The voltage $V$ in a circuit is given by $V = \sqrt{PR}$, where $P$ is the power in watts and $R$ is the resistance in ohms.

- **a.** If the voltage in a circuit is 120 volts and the circuit produces 1500 watts of power, what is the resistance in the circuit?
- **b.** Suppose an electrician designs a circuit with 110 volts and a resistance of 10 ohms. How much power will the circuit produce?

**24. FREE FALL** Assuming no air resistance, the time $t$ in seconds that it takes an object to fall $h$ feet can be determined by the equation $t = \frac{\sqrt{h}}{4}$.

- **a.** If a skydiver jumps from an airplane and free falls for 10 seconds before opening the parachute, how many feet does the skydiver fall?
- **b.** Suppose a second skydiver jumps and free falls for 6 seconds. How many feet does the second skydiver fall?
1. **SUBMARINES** The distance in miles that the lookout of a submarine can see is approximately \( d = 1.22\sqrt{h} \), where \( h \) is the height in feet above the surface of the water. How far would a submarine periscope have to be above the water to locate a ship 6 miles away? Round your answer to the nearest tenth.

2. **PETS** Find the value of \( x \) if the perimeter of a triangular dog pen is 25 meters.

   ![Diagram of triangle with sides 12 m, 10 m, and \( \sqrt{x+1} \) m]

3. **LOGGING** Doyle’s log rule estimates the amount of usable lumber (in board feet) that can be milled from a shipment of logs. It is represented by the equation \( B = L\left(\frac{d-4}{4}\right)^2 \), where \( d \) is the log diameter (in inches) and \( L \) is the log length (in feet). Suppose the truck carries 20 logs, each 25 feet long, and that the shipment yields a total of 6000 board feet of lumber. Estimate the diameter of the logs to the nearest inch. Assume that all the logs have uniform length and diameter.

4. **FIREFIGHTING** Firefighters calculate the flow rate of water out of a particular hydrant by using the following formula.

\[
F = 26.9d^2\sqrt{p}
\]

\( F \) is the flow rate (in gallons per minute), \( p \) is the nozzle pressure (in pounds per square inch), and \( d \) is the diameter of the hose (in inches). In order to effectively fight a fire, the combined flow rate of two hoses needs to be about 2430 gallons per minute. The diameter of each of the hoses is 3 inches, but the nozzle pressure of one hose is 4 times that of the second hose. What are the nozzle pressures for each hose? Round your answers to the nearest tenth.

5. **GEOMETRY** The lateral surface area \( s \) of a right circular cone, not including the base, is represented by the equation \( s = \pi r \sqrt{r^2 + h^2} \), where \( r \) is the radius of the circular base and \( h \) is the height of the cone.

   a. If the lateral surface area of a funnel is 127.54 square centimeters and its radius is 3.5 centimeters, find its height to the nearest tenth of a centimeter.

   b. What is the area of the opening (i.e., the base) of the funnel?
More Than One Square Root
You have learned that to remove the square root in an equation, you first need to isolate the square root, then square both sides of the equation, and finally, solve the resulting equation. However, there are equations that contain more than one square root and simply squaring once is not enough to remove all of the radicals.

Example
Solve \( \sqrt{x + 7} = \sqrt{x} + 1 \).

\[
\begin{align*}
\sqrt{x + 7} &= \sqrt{x} + 1 \\
(x + 7) &= (\sqrt{x} + 1)^2 \\
x + 7 &= x + 2\sqrt{x} + 1 \\
x + 7 - x - 1 &= 2\sqrt{x} \\
6 &= 2\sqrt{x} \\
3 &= \sqrt{x} \\
9 &= x
\end{align*}
\]

Check: Substitute into the original equation to make sure your solution is valid.

\[
\begin{align*}
\sqrt{9 + 7} &= \sqrt{9} + 1 \\
\sqrt{16} &= 3 + 1 \\
4 &= 4 \checkmark
\end{align*}
\]

The equation is true, so \( x = 9 \) is the solution.

Exercises
Solve each equation.

1. \( \sqrt{x + 13} - 2 = \sqrt{x} + 1 \) 
2. \( \sqrt{x + 11} = \sqrt{x} + 3 + 2 \)
3. \( \sqrt{x + 9} - 3 = \sqrt{x} - 6 \) 
4. \( \sqrt{x + 21} = \sqrt{x} + 3 \)
5. \( \sqrt{x + 9} + 3 = \sqrt{x} + 20 + 2 \) 
6. \( \sqrt{x - 6} + 6 = \sqrt{x} + 1 + 5 \)
Graphing Calculator Activity

Radical Inequalities

The graphs of radical equations can be used to determine the solutions of radical inequalities through the CALC menu.

Example
Solve each inequality.

a. $\sqrt{x + 4} \leq 3$

Enter $\sqrt{x + 4}$ in Y1 and 3 in Y2 and graph. Examine the graphs. Use TRACE to find the endpoint of the graph of the radical equation. Use CALC to determine the intersection of the graphs. This interval, $-4 \leq x \leq 5$, where the graph of $y = \sqrt{x + 4}$ is below the graph of $y = 3$, represents the solution to the inequality. Thus, the solution is $-4 \leq x \leq 5$.

b. $\sqrt{2x - 5} > x - 4$

Graph each side of the inequality. Find the intersection and trace to the endpoint of the radical graph.

The graph of $y = \sqrt{2x - 5}$ is above the graph of $y = x - 4$ from 2.5 up to 7. Thus, the solution is $2.5 < x < 7$.

Exercises
Solve each inequality.

1. $6 - \sqrt{2x + 1} < 3$
2. $\sqrt{4x - 5} \leq 7$
3. $\sqrt{5x - 4} \geq 4$

4. $-4 > \sqrt{3x - 2}$
5. $\sqrt{3x - 6} + 5 \geq -3$
6. $\sqrt{6 - 3x} < x + 16$
The Pythagorean Theorem

The side opposite the right angle in a right triangle is called the hypotenuse. This side is always the longest side of a right triangle. The other two sides are called the legs of the triangle. To find the length of any side of a right triangle, given the lengths of the other two sides, you can use the Pythagorean Theorem.

**Pythagorean Theorem**

If \(a\) and \(b\) are the measures of the legs of a right triangle and \(c\) is the measure of the hypotenuse, then \(c^2 = a^2 + b^2\).

**Example**

Find the length of the missing side.

\[ c^2 = a^2 + b^2 \quad \text{Pythagorean Theorem} \]
\[ c^2 = 5^2 + 12^2 \quad a = 5 \text{ and } b = 12 \]
\[ c^2 = 169 \quad \text{Simplify} \]
\[ c = \sqrt{169} \quad \text{Take the square root of each side} \]
\[ c = 13 \]

The length of the hypotenuse is 13.

**Exercises**

Find the length of each missing side. If necessary, round to the nearest hundredth.

1. 

2. 

3. 

4. 

5. 

6.
The Pythagorean Theorem

Right Triangles If \(a\) and \(b\) are the measures of the shorter sides of a triangle, \(c\) is the measure of the longest side, and \(c^2 = a^2 + b^2\), then the triangle is a right triangle.

Example Determine whether the following side measures form right triangles.

a. 10, 12, 14
Since the measure of the longest side is 14, let \(c = 14\), \(a = 10\), and \(b = 12\).

\[
c^2 = a^2 + b^2 \quad \text{Pythagorean Theorem}
\]
\[
14^2 \neq 10^2 + 12^2 \quad a = 10, \ b = 12, \ c = 14
\]
\[
196 \neq 100 + 144 \quad \text{Multiply.}
\]
\[
196 \neq 244 \quad \text{Add.}
\]
Since \(c^2 \neq a^2 + b^2\), the triangle is not a right triangle.

b. 7, 24, 25
Since the measure of the longest side is 25, let \(c = 25\), \(a = 7\), and \(b = 24\).

\[
c^2 = a^2 + b^2 \quad \text{Pythagorean Theorem}
\]
\[
25^2 \neq 7^2 + 24^2 \quad a = 7, \ b = 24, \ c = 25
\]
\[
625 \neq 49 + 576 \quad \text{Multiply.}
\]
\[
625 = 625 \quad \text{Add.}
\]
Since \(c^2 = a^2 + b^2\), the triangle is a right triangle.

Exercises

Determine whether each set of measures can be sides of a right triangle. Then determine whether they form a Pythagorean triple.

1. 14, 48, 50
2. 6, 8, 10
3. 8, 8, 10
4. 90, 120, 150
5. 15, 20, 25
6. 4, 8, \(4\sqrt{5}\)
7. 2, 2, \(\sqrt{8}\)
8. 4, 4, \(\sqrt{20}\)
9. 25, 30, 35
10. 24, 36, 48
11. 18, 80, 82
12. 150, 200, 250
13. 100, 200, 300
14. 500, 1200, 1300
15. 700, 1000, 1300
10-5 Skills Practice

The Pythagorean Theorem

Find the length of each missing side. If necessary, round to the nearest hundredth.

1. \( \sqrt{21^2 - 7^2} \)

2. \( \sqrt{39^2 - 15^2} \)

3. \( \sqrt{16^2 - 34^2} \)

4. \( \sqrt{29^2 - 33^2} \)

5. \( \sqrt{4^2 - 9^2} \)

6. \( \sqrt{240^2 - 250^2} \)

Determine whether each set of measures can be sides of a right triangle. Then determine whether they form a Pythagorean triple.

7. 7, 24, 25

8. 15, 30, 34

9. 16, 28, 32

10. 18, 24, 30

11. 15, 36, 39

12. 5, 7, \( \sqrt{74} \)

13. 4, 5, 6

14. 10, 11, \( \sqrt{221} \)
10-5 Practice

The Pythagorean Theorem

Find the length of each missing side. If necessary, round to the nearest hundredth.

1. \[ \triangle \]
   \[ \begin{array}{c}
   32 \\
   c \\
   60 \\
   \end{array} \]

2. \[ \triangle \]
   \[ \begin{array}{c}
   a \\
   11 \\
   19 \\
   \end{array} \]

3. \[ \triangle \]
   \[ \begin{array}{c}
   4 \\
   b \\
   12 \\
   \end{array} \]

Determine whether each set of measures can be sides of a right triangle. Then determine whether they form a Pythagorean triple.

4. 11, 18, 21

5. 21, 72, 75

6. 7, 8, 11

7. 9, 10, \( \sqrt{161} \)

8. 9, \( 2\sqrt{10} \), 11

9. \( \sqrt{7} \), \( 2\sqrt{2} \), \( \sqrt{15} \)

10. STORAGE The shed in Stephan’s back yard has a door that measures 6 feet high and 3 feet wide. Stephan would like to store a square theater prop that is 7 feet on a side. Will it fit through the door diagonally? Explain.

11. SCREEN SIZES The size of a television is measured by the length of the screen’s diagonal.

   a. If a television screen measures 24 inches high and 18 inches wide, what size television is it?

   b. Darla told Tri that she has a 35-inch television. The height of the screen is 21 inches. What is its width?

   c. Tri told Darla that he has a 5-inch handheld television and that the screen measures 2 inches by 3 inches. Is this a reasonable measure for the screen size? Explain.
1. **BASEBALL** A baseball diamond is a square. Each base path is 90 feet long. After a pitch, the catcher quickly throws the ball from home plate to a teammate standing by second base. Find the distance the ball travels. Round your answer to the nearest tenth.

2. **TRIANGLES** Each student in Mrs. Kelly’s geometry class constructed a unique right triangle from drinking straws. Mrs. Kelly made a chart with the dimensions of each triangle. However, Mrs. Kelly made a mistake when recording their results. Which result was recorded incorrectly?

<table>
<thead>
<tr>
<th>Side Lengths</th>
<th>Student</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>Student</th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amy</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>Fran</td>
<td>8</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Belinda</td>
<td>7</td>
<td>24</td>
<td>25</td>
<td>Gus</td>
<td>5</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Emory</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. **MAPS** Find the distance between Macon and Berryville. Round your answer to the nearest tenth.

4. **TELEVISION** Televisions are identified by the diagonal measurement of the viewing screen. For example, a 27-inch television has a diagonal screen measurement of 27 inches.

Complete the chart to find the screen height of each television given its size and screen width. Round your answers to the nearest whole number.

<table>
<thead>
<tr>
<th>TV size</th>
<th>width (in.)</th>
<th>height (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-inch</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>25-inch</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>32-inch</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>50-inch</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Best Buy

5. **MANUFACTURING** Karl works for a company that manufactures car parts. His job is to drill a hole in spherical steel balls. The balls and the holes have the dimensions shown on the diagram.

a. How deep is the hole?

b. What would be the radius of a ball with a similar hole 7 centimeters wide and 24 centimeters deep?
Enrichment

Pythagorean Triples

Recall the Pythagorean Theorem:
In a right triangle, the square of the length of the hypotenuse is equal to the sum of the squares of the lengths of the legs.

\[ a^2 + b^2 = c^2 \]

The integers 3, 4, and 5 satisfy the Pythagorean Theorem and can be the lengths of the sides of a right triangle.

Furthermore, for any positive integer \( n \), the numbers \( 3n \), \( 4n \), and \( 5n \) satisfy the Pythagorean Theorem.

If three numbers satisfy the Pythagorean Theorem, they are called a **Pythagorean triple**. Here is an easy way to find other Pythagorean triples.

The numbers \( a \), \( b \), and \( c \) are a Pythagorean triple if \( a = m^2 - n^2 \), \( b = 2mn \), and \( c = m^2 + n^2 \), where \( m \) and \( n \) are relatively prime positive integers and \( m > n \).

**Example**

Choose \( m = 5 \) and \( n = 2 \).

\[
\begin{align*}
  a &= m^2 - n^2 \\
  &= 5^2 - 2^2 \\
  &= 25 - 4 \\
  &= 21 \\
  b &= 2mn \\
  &= 2(5)(2) \\
  &= 20 \\
  c &= m^2 + n^2 \\
  &= 5^2 + 2^2 \\
  &= 25 + 4 \\
  &= 29
\end{align*}
\]

**Check**

\[ 20^2 + 21^2 = 29^2 \]

\[ 400 + 441 = 841 \]

Exercises

Use the following values of \( m \) and \( n \) to find Pythagorean triples.

1. \( m = 3 \) and \( n = 2 \) 
2. \( m = 4 \) and \( n = 1 \) 
3. \( m = 5 \) and \( n = 3 \) 
4. \( m = 6 \) and \( n = 5 \) 
5. \( m = 10 \) and \( n = 7 \) 
6. \( m = 8 \) and \( n = 5 \)
10-5 Spreadsheet Activity

Pythagorean Triples

A **Pythagorean triple** is a set of three whole numbers that satisfies the equation $a^2 + b^2 = c^2$, where $c$ is the greatest number. You can use a spreadsheet to investigate the patterns in Pythagorean triples. A **primitive Pythagorean triple** is a Pythagorean triple in which the numbers have no common factors other than 1. A **family of Pythagorean triples** is a primitive Pythagorean triple and its whole number multiples.

The spreadsheet at the right produces a family of Pythagorean triples.

**Step 1** Enter a Pythagorean triple into cells A1, A2, and A3.

**Step 2** Use rows 2 through 10 to find 9 additional Pythagorean triples that are multiples of the primitive triple. Format the rows so that row 2 multiplies the numbers in row 1 by 2, row 3 multiplies the numbers in row 1 by 3, and so on.

![Spreadsheet](image)

The formula in cell A10 is $A1 \times 10$.

**Exercises**

Use the spreadsheet of families of Pythagorean triples.

1. Choose one of the triples other than (3, 4, 5) from the spreadsheet. Verify that it is a Pythagorean triple.

2. Two polygons are **similar** if they are the same shape, but not necessarily the same size. For triangles, if two triangles have angles with the same measures then they are similar. Use a centimeter ruler to draw triangles with measures from the spreadsheet. Do the triangles appear to be similar?

Each of the following is a primitive Pythagorean triple. Use the spreadsheet to find two Pythagorean triples in their families.

3. (5, 12, 13)

4. (9, 40, 41)

5. (20, 21, 29)
10-6 Study Guide and Intervention

The Distance and Midpoint Formulas

Distance Formula The Pythagorean Theorem can be used to derive the Distance Formula shown below. The Distance Formula can then be used to find the distance between any two points in the coordinate plane.

| Distance Formula | The distance between any two points with coordinates \((x_1, y_1)\) and \((x_2, y_2)\) is given by \(d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}\) |

Example 1 Find the distance between the points at \((-5, 2)\) and \((4, 5)\).

\[
d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad \text{Distance Formula}
\]
\[
= \sqrt{(4 - (-5))^2 + (5 - 2)^2} \quad (x_1, y_1) = (-5, 2), (x_2, y_2) = (4, 5)
\]
\[
= \sqrt{9^2 + 3^2} \quad \text{Simplify.}
\]
\[
= \sqrt{81 + 9} \quad \text{Evaluate squares and simplify.}
\]
\[
= \sqrt{90}
\]

The distance is \(\sqrt{90}\), or about 9.49 units.

Example 2 Jill draws a line segment from point \((1, 4)\) on her computer screen to point \((98, 49)\). How long is the segment?

\[
d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad \text{Distance Formula}
\]
\[
= \sqrt{(98 - 1)^2 + (49 - 4)^2} \quad (x_1, y_1) = (1, 4), (x_2, y_2) = (98, 49)
\]
\[
= \sqrt{97^2 + 45^2}
\]
\[
= \sqrt{9409 + 2025}
\]
\[
= \sqrt{11434}
\]

The segment is about 106.93 units long.

Exercises

Find the distance between the points with the given coordinates.

1. \((1, 5), (3, 1)\)
2. \((0, 0), (6, 8)\)
3. \((-2, -8), (7, -3)\)
4. \((6, -7), (-2, 8)\)
5. \((1, 5), (-8, 4)\)
6. \((3, -4), (-4, -4)\)
7. \((-1, 4), (3, 2)\)
8. \((0, 0), (-3, 5)\)
9. \((2, -6), (-7, 1)\)
10. \((-2, -5), (0, 8)\)
11. \((3, 4), (0, 0)\)
12. \((3, -4), (-4, -16)\)

Find the possible values of \(a\) if the points with the given coordinates are the indicated distance apart.

13. \((1, a), (3, -2); d = \sqrt{5}\)
14. \((0, 0), (a, 4); d = 5\)
15. \((2, -1), (a, 3); d = 5\)
16. \((1, -3), (a, 21); d = 25\)
17. \((1, a), (-2, 4); d = 3\)
18. \((3, -4), (-4, a); d = \sqrt{65}\)
10-6 Study Guide and Intervention (continued)

**The Distance and Midpoint Formulas**

**Midpoint Formula** The point that is equidistance from both of the endpoints is called the **midpoint**. You can find the coordinates of the midpoint by using the Midpoint Formula.

<table>
<thead>
<tr>
<th>Midpoint Formula</th>
<th>The midpoint $M$ of a line segment with endpoints at $(x_1, y_1)$ and $(x_2, y_2)$ is given by $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$.</th>
</tr>
</thead>
</table>

**Example 1** Find the coordinates of the midpoint of the segment with endpoints at $(-2, 5)$ and $(4, 9)$.

$$M \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$$  

Midpoint Formula

$$= M \left(\frac{-2 + 4}{2}, \frac{5 + 9}{2}\right)$$  

$(x_1, y_1) = (-2, 5)$ and $(x_2, y_2) = (4, 9)$

$$= M \left(\frac{2}{2}, \frac{14}{2}\right)$$  

Simplify the numerators.

$$= M (1, 3)$$  

Simplify.

**Exercises**

Find the coordinates of the midpoint of the segment with the given endpoints.

1. $(1, 6), (3, 10)$  
2. $(4, -2), (0, 6)$  
3. $(7, 2), (13, -4)$

4. $(-1, 2), (1, 0)$  
5. $(-3, -3), (5, -11)$  
6. $(0, 8), (-6, 0)$

7. $(4, -3), (-2, 3)$  
8. $(9, -1), (3, -7)$  
9. $(2, -1), (8, 7)$

10. $(1, 4), (-3, 12)$  
11. $(4, 0), (-2, 6)$  
12. $(1, 9), (7, 1)$

13. $(12, 0), (2, -6)$  
14. $(1, 1), (9, -9)$  
15. $(4, 5), (-2, -1)$

16. $(1, -14), (-5, 0)$  
17. $(2, 2), (6, 8)$  
18. $(-7, 3), (5, -3)$
10-6 Skills Practice

The Distance and Midpoint Formulas

Find the distance between the points with the given coordinates.

1. (9, 7), (1, 1)  
2. (5, 2), (8, −2)  
3. (1, −3), (1, 4)  
4. (7, 2), (−5, 7)  
5. (−6, 3), (10, 3)  
6. (3, 3), (−2, 3)  
7. (−1, −4), (−6, 0)  
8. (−2, 4), (5, 8)

Find the possible values of $a$ if the points with the given coordinates are the indicated distance apart.

9. (−2, −5), (a, 7); $d = 13$  
10. (8, −2), (5, a); $d = 3$  
11. (4, a), (1, 6); $d = 5$  
12. (a, 3), (5, −1); $d = 5$  
13. (1, 1), (a, 1); $d = 4$  
14. (2, a), (2, 3); $d = 10$  
15. (a, 2), (−3, 3); $d = √2$  
16. (−5, 3), (−3, a); $d = √5$

Find the coordinates of the midpoint of the segment with the given endpoints.

17. (−3, 4), (−2, 8)  
18. (5, −6), (7, −9)  
19. (4, 2), (8, 6)  
20. (5, 2), (3, 10)  
21. (12, −1), (4, −11)  
22. (−3, −1), (−11, 3)  
23. (9, 3), (6, −6)  
24. (0, −4), (8, 4)
10-6 Practice

The Distance and Midpoint Formulas

Find the distance between the points with the given coordinates.

1. (4, 7), (1, 3)  
2. (0, 9), (−7, −2)

3. (6, 2), + (4, 1/2)  
4. (−1, 7), + (1/3, 6)

5. (√3, 3), (2√3, 5)  
6. (2√2, −1), (3√2, 3)

Find the possible values of \(a\) if the points with the given coordinates are the indicated distance apart.

7. (4, −1), (a, 5); \(d = 10\)  
8. (2, −5), (a, 7); \(d = 15\)

9. (6, −7), (a, −4); \(d = √18\)  
10. (−4, 1), (a, 8); \(d = √50\)

11. (8, −5), (a, 4); \(d = √85\)  
12. (−9, 7), (a, 5); \(d = √29\)

Find the coordinates of the midpoint of the segment with the given endpoints.

13. (4, −6), (3, −9)  
14. (−3, −8), (−7, 2)

15. (0, −4), (3, 2)  
16. (−13, −9), (−1, −5)

17. \(\left(2, −\frac{1}{2}\right), \left(1, \frac{1}{2}\right)\)  
18. \(\left(\frac{2}{3}, −1\right), \left(2, \frac{1}{3}\right)\)

19. BASEBALL  Three players are warming up for a baseball game. Player B stands 9 feet to the right and 18 feet in front of Player A. Player C stands 8 feet to the left and 13 feet in front of Player A.

   a. Draw a model of the situation on the coordinate grid. Assume that Player A is located at (0, 0).

   b. To the nearest tenth, what is the distance between Players A and B and between Players A and C?

   c. What is the distance between Players B and C?

20. MAPS  Maria and Jackson live in adjacent neighborhoods. If they superimpose a coordinate grid on the map of their neighborhoods, Maria lives at (−9, 1) and Jackson lives at (5, −4).
Word Problem Practice

The Distance and Midpoint Formulas

1. CHESS  Margaret’s last two remaining chess pieces are located at the centers of the squares at opposite corners of the board. If the chessboard is a square with 8-inch sides, about how far apart are the pieces? Round your answer to the nearest tenth.

2. ENGINEERING  Todd has drawn a cul-de-sac for a residential development plan. He used a compass to draw the cul-de-sac so that it would be circular. On his blueprint, the center of the cul-de-sac has coordinates (\(-1, -1\)) and a point on the circle is (2, 3). What is the radius of the cul-de-sac?

3. LANDSCAPING  Randy plotted a triangular patio on a landscape plan for a client. What is the length of fencing he will need along the patio edge that borders the property line? Round your answer to the nearest tenth.

4. UTILITIES  The electric company is running some wires across an open field. The wire connects a utility pole at (2, 14) and a second utility pole at (7, -8). If the electric company wishes to place a third pole at the midpoint of the two poles, at what coordinates should the pole be placed?

5. MARCHING BAND  The Ohio State University marching band performs a famous on-field spelling of O-H-I-O called “Script Ohio”. Sometimes they must adjust the usual dimensions of the word to fit it into the limited guest band performance area. The diagram below shows part of the adjusted drill chart. Each point represents one band member, and the coordinates are in yards.

\[
\begin{align*}
(20, 13) & \quad \text{tuba player} \\
(32, 10) & \quad \text{drum major}
\end{align*}
\]

a. How far is the drum major from the tuba player who dots the “i”?

b. Carol is the band member at the top left of the first O in Ohio. She is located at (0, 26). How far away is Carol from the tuba player? Round your answer to the nearest tenth.
A Space-Saving Method

Two arrangements for cookies on a 32 cm by 40 cm cookie sheet are shown at the right. The cookies have 8-cm diameters after they are baked. The centers of the cookies are on the vertices of squares in the top arrangement. In the other, the centers are on the vertices of equilateral triangles. Which arrangement is more economical? The triangle arrangement is more economical, because it contains one more cookie.

In the square arrangement, rows are placed every 8 cm. At what intervals are rows placed in the triangle arrangement?

Look at the right triangle labeled $a$, $b$, and $c$. A leg $a$ of the triangle is the radius of a cookie, or 4 cm. The hypotenuse $c$ is the sum of two radii, or 8 cm. Use the Pythagorean theorem to find $b$, the interval of the rows.

$$c^2 = a^2 + b^2$$

$$8^2 = 4^2 + b^2$$

$$64 - 16 = b^2$$

$$\sqrt{48} = b$$

$$4\sqrt{3} = b$$

$$b = 4\sqrt{3} \approx 6.93$$

The rows are placed approximately every 6.93 cm.

Solve each problem.

1. Suppose cookies with 10-cm diameters are arranged in the triangular pattern shown above. What is the interval $b$ of the rows?

2. Find the diameter of a cookie if the rows are placed in the triangular pattern every $3\sqrt{3}$ cm.

3. Describe other practical applications in which this kind of triangular pattern can be used to economize on space.
Similar Triangles

Similar Triangles \( \triangle RST \) is similar to \( \triangle XYZ \). The angles of the two triangles have equal measure. They are called corresponding angles. The sides opposite the corresponding angles are called corresponding sides.

<table>
<thead>
<tr>
<th>Similar Triangles</th>
<th>If two triangles are similar, then the measures of their corresponding sides are proportional and the measures of their corresponding angles are equal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \triangle ABC \sim \triangle DEF )</td>
<td>( \frac{AB}{DE} = \frac{BC}{EF} = \frac{AC}{DF} )</td>
</tr>
</tbody>
</table>

Example 1

Determine whether the pair of triangles is similar. Justify your answer.

Since corresponding angles do not have the equal measures, the triangles are not similar.

Example 2

Determine whether the pair of triangles is similar. Justify your answer.

The measure of \( \angle G = 180° - (90° + 45°) = 45° \). The measure of \( \angle I = 180° - (45° + 45°) = 90° \). Since corresponding angles have equal measures, \( \triangle EFG \sim \triangle HIJ \).

Exercises

Determine whether each pair of triangles is similar. Justify your answer.

1. \( \triangle ABC \)
2. \( \triangle DEF \)
3. \( \triangle GHI \)
4. \( \triangle JKL \)
5. \( \triangle MNO \)
6. \( \triangle PQR \)
10-7 Study Guide and Intervention (continued)

Similar Triangles

Find Unknown Measures If some of the measurements are known, proportions can be used to find the measures of the other sides of similar triangles.

Example

INDIRECT MEASUREMENT

\(\triangle ABC \sim \triangle AED\) in the figure at the right.
Find the height of the apartment building.

Let \(BC = x\).

\[
\frac{ED}{BC} = \frac{AD}{AC} \quad \frac{7}{x} = \frac{25}{300}
\]

Find the cross products.

\[
x = 84
\]

The apartment building is 84 meters high.

Exercises

Find the missing measures for the pair of similar triangles if \(\triangle ABC \sim \triangle DEF\).

1. \(c = 15, \, d = 8, \, e = 6, \, f = 10\)

2. \(c = 20, \, a = 12, \, b = 8, \, f = 15\)

3. \(a = 8, \, d = 8, \, e = 6, \, f = 7\)

4. \(a = 20, \, d = 10, \, e = 8, \, f = 10\)

5. \(c = 5, \, d = 10, \, e = 8, \, f = 8\)

6. \(a = 25, \, b = 20, \, c = 15, \, f = 12\)

7. \(b = 8, \, d = 8, \, e = 4, \, f = 10\)

8. INDIRECT MEASUREMENT Bruce likes to amuse his brother by shining a flashlight on his hand and making a shadow on the wall. How far is it from the flashlight to the wall?

9. INDIRECT MEASUREMENT A forest ranger uses similar triangles to find the height of a tree. Find the height of the tree.
10-7 Skills Practice

Similar Triangles

Determine whether each pair of triangles is similar. Justify your answer.

1. \( \triangle ABC \) and \( \triangle DEF \)

2. \( \triangle UVW \) and \( \triangle XYZ \)

Find the missing measures for the pair of similar triangles if \( \triangle PQR \sim \triangle STU \).

5. \( r = 4, s = 6, t = 3, u = 2 \)

6. \( t = 8, p = 21, q = 14, r = 7 \)

7. \( p = 15, q = 10, r = 5, s = 6 \)

8. \( p = 48, s = 16, t = 8, u = 4 \)

9. \( q = 6, s = 2, t = \frac{3}{2}, u = \frac{1}{2} \)

10. \( p = 3, q = 2, r = 1, u = \frac{1}{3} \)

11. \( p = 14, q = 7, u = 2.5, t = 5 \)

12. \( r = 6, s = 3, t = \frac{21}{8}, u = \frac{9}{4} \)
10-7 Practice

Similar Triangles

Determine whether each pair of triangles is similar. Justify your answer.

1. \( \triangle RST \) and \( \triangle UVP \)

2. \( \triangle DEF \) and \( \triangle GHI \)

Find the missing measures for the pair of similar triangles if \( \triangle ABC \sim \triangle DEF \).

3. \( c = 4, d = 12, e = 16, f = 8 \)

4. \( e = 20, a = 24, b = 30, c = 15 \)

5. \( a = 10, b = 12, c = 6, d = 4 \)

6. \( a = 4, d = 6, e = 4, f = 3 \)

7. \( b = 15, d = 16, e = 20, f = 10 \)

8. \( a = 16, b = 22, c = 12, f = 8 \)

9. \( a = \frac{5}{2}, b = 3, f = \frac{11}{2}, e = 7 \)

10. \( c = 4, d = 6, e = 5.625, f = 12 \)

11. SHADOWS Suppose you are standing near a building and you want to know its height. The building casts a 66-foot shadow. You cast a 3-foot shadow. If you are 5 feet 6 inches tall, how tall is the building?

12. MODELS Truss bridges use triangles in their support beams. Molly made a model of a truss bridge in the scale of 1 inch = 8 feet. If the height of the triangles on the model is 4.5 inches, what is the height of the triangles on the actual bridge?
10-7 **Word Problem Practice**

**Similar Triangles**

1. **CRAFTS** Layla is wants to buy a set of similar magnets for her refrigerator door. Layla finds the magnets below for sale at a local shop. Which two are similar?

   ![Diagram of similar triangles](image)

2. **EXHIBITIONS** The world’s largest candle was displayed at the 1897 Stockholm Exhibition. Suppose Lars measured the length of the shadow it cast at 11:00 A.M. and found that it was 12 feet. Suppose that immediately after this, he measured to find that a nearby 25-foot tent pole cast a shadow 5 feet long. How tall was the world’s largest candle?

3. **LANDMARKS** The Toy and Miniature Museum of Kansas City displays a miniature replica of George Washington’s Mount Vernon mansion. The miniature house is 10 feet long, 6 feet wide, 8 feet tall, and has 22 rooms. The scale of the model to the original is one inch to one foot. If the roof gable of the miniature has dimensions as shown on the diagram below, what is the height of the roof gable on the original Mount Vernon mansion?

   ![Diagram of Mount Vernon roof gable](image)

4. **SURVEYING** Surveyors use properties of triangles including similarity and the Pythagorean Theorem to find unknown distances. Use the dimensions on the diagram to find the unknown distance $x$ across the lake.

   ![Diagram of surveying](image)

5. **PUZZLES** The figure below shows an ancient Chinese movable puzzle called a tangram. It has 7 pieces that can be reconfigured to produce an endless number of designs and pictures.

   ![Diagram of tangram](image)

Assume that the side length of this tangram square is $\sqrt{2}$ cm. Leave your answers as simplified radical expressions.

   a. What are the side lengths of triangles 1 and 2?

   b. What are the side lengths of triangle 7?

   c. What are the side lengths of triangles 3 and 5?
A Curious Construction

Many mathematicians have been interested in ways to construct the number $\pi$. Here is one such geometric construction.

In the drawing, triangles $ABC$ and $ADE$ are right triangles. The length of $AD$ equals the length of $AC$ and $FB$ is parallel to $EG$.

The length of $BG$ gives a decimal approximation of the fractional part of $\pi$ to six decimal places.

Follow the steps to find the length of $BG$. Round to seven decimal places.

1. Use the length of $BC$ and the Pythagorean Theorem to find the length of $AC$.

2. Find the length of $AD$.

3. Use the length of $AD$ and the Pythagorean Theorem to find the length of $AE$.

4. The sides of the similar triangles $FED$ and $DEA$ are in proportion. So, $\frac{FE}{0.5} = \frac{AE}{0.5}$. Find the length of $FE$.

5. Find the length of $AF$.

6. The sides of the similar triangles $AFB$ and $AEG$ are in proportion. So, $\frac{AF}{AE} = \frac{AB}{AG}$. Find the length of $AG$.

7. Now, find the length of $BG$.

8. The value of $\pi$ to seven decimal places is 3.1415927. Compare the fractional part of pi with the length of $BG$. 
10-8 Study Guide and Intervention

Trigonometric Ratios

Trigonometry is the study of relationships of the angles and the sides of a right triangle. The three most common trigonometric ratios are the sine, cosine, and tangent.

\[
\text{sine of } \angle A = \frac{\text{leg opposite } \angle A}{\text{hypotenuse}}
\]
\[
\sin A = \frac{a}{c}
\]
\[
\text{sine of } \angle B = \frac{\text{leg opposite } \angle B}{\text{hypotenuse}}
\]
\[
\sin B = \frac{b}{c}
\]
\[
\text{cosine of } \angle A = \frac{\text{leg adjacent to } \angle A}{\text{hypotenuse}}
\]
\[
\cos A = \frac{b}{c}
\]
\[
\text{cosine of } \angle B = \frac{\text{leg adjacent to } \angle B}{\text{hypotenuse}}
\]
\[
\cos B = \frac{a}{c}
\]
\[
\text{tangent of } \angle A = \frac{\text{leg opposite } \angle A}{\text{leg adjacent to } \angle A}
\]
\[
\tan A = \frac{a}{b}
\]
\[
\text{tangent of } \angle B = \frac{\text{leg opposite } \angle B}{\text{leg adjacent to } \angle B}
\]
\[
\tan B = \frac{b}{a}
\]

Example

Find the values of the three trigonometric ratios for angle \(A\).

Step 1 Use the Pythagorean Theorem to find \(BC\).

\[
a^2 + b^2 = c^2
\]
Pythagorean Theorem

\[
a^2 + 8^2 = 10^2
\]
\(b = 8\) and \(c = 10\)

\[
a^2 + 64 = 100
\]
Simplify.

\[
a^2 = 36
\]
Subtract 64 from both sides.

\[
a = 6
\]
Take the square root of each side.

Step 2 Use the side lengths to write the trigonometric ratios.

\[
\sin A = \frac{\text{opp}}{\text{hyp}} = \frac{6}{10} = \frac{3}{5}
\]
\[
\cos A = \frac{\text{adj}}{\text{hyp}} = \frac{8}{10} = \frac{4}{5}
\]
\[
\tan A = \frac{\text{opp}}{\text{adj}} = \frac{6}{8} = \frac{3}{4}
\]

Exercises

Find the values of the three trigonometric ratios for angle \(A\).

1. \(A\)

2. \(A\)

3. 

Use a calculator to find the value of each trigonometric ratio to the nearest ten-thousandth.

4. \(\sin 40^\circ\)  
5. \(\cos 25^\circ\)  
6. \(\tan 85^\circ\)
10-8 Study Guide and Intervention (continued)

Trigonometric Ratios

Use Trigonometric Ratios When you find all of the unknown measures of the sides and angles of a right triangle, you are solving the triangle. You can find the missing measures of a right triangle if you know the measure of two sides of the triangle, or the measure of one side and the measure of one acute angle.

Example Solve the triangle. Round each side length to the nearest tenth.

Step 1 Find the measure of \( \angle B \). The sum of the measures of the angles in a triangle is 180.
\[
180° - (90° + 38°) = 52°
\]
The measure of \( \angle B \) is 52°.

Step 2 Find the measure of \( \overline{AB} \). Because you are given the measure of the side adjacent to \( \angle A \) and are finding the measure of the hypotenuse, use the cosine ratio.
\[
\cos 38° = \frac{13}{c} \quad \text{Definition of cosine}
\]
\[
c \cos 38° = 13 \quad \text{Multiply each side by } c.
\]
\[
c = \frac{13}{\cos 38°} \quad \text{Divide each side by } \sin 41°.
\]
So the measure of \( \overline{AB} \) is about 16.5.

Step 3 Find the measure of \( \overline{BC} \). Because you are given the measure of the side adjacent to \( \angle A \) and are finding the measure of the side opposite \( \angle A \), use the tangent ratio.
\[
\tan 38° = \frac{a}{13} \quad \text{Definition of tangent}
\]
\[
13 \tan 38° = a \quad \text{Multiply each side by 13.}
\]
\[
10.2 \approx a \quad \text{Use a calculator.}
\]
So the measure of \( \overline{BC} \) is about 10.2.

Exercises

Solve each right triangle. Round each side length to the nearest tenth.

1. 

2. 

3. 

10-8 Skills Practice

Trigonometric Ratios

Find the values of the three trigonometric ratios for angle $A$.

1. \[
\begin{align*}
&\; A \quad 85 \\
&\quad C \quad 77 \quad B
\end{align*}
\]

2. \[
\begin{align*}
&\; A \quad 15 \quad 9 \\
&\quad B \quad C
\end{align*}
\]

3. \[
\begin{align*}
&\; A \quad 10 \quad 24 \\
&\quad C \quad 12 \\
&\quad B
\end{align*}
\]

4. \[
\begin{align*}
&\; A \quad 15 \\
&\quad B
\end{align*}
\]

Use a calculator to find the value of each trigonometric ratio to the nearest ten-thousandth.

5. $\sin 18^\circ$  
6. $\cos 68^\circ$  
7. $\tan 27^\circ$

8. $\cos 60^\circ$  
9. $\tan 75^\circ$  
10. $\sin 9^\circ$

Solve each right triangle. Round each side length to the nearest tenth.

11. \[
\begin{align*}
&\; A \quad 17^\circ \\
&\quad B \quad 13 \\
&\quad C
\end{align*}
\]

12. \[
\begin{align*}
&\; A \quad 55^\circ \\
&\quad B \quad 6 \\
&\quad C
\end{align*}
\]

Find $m \angle J$ for each right triangle to the nearest degree.

13. \[
\begin{align*}
&\; L \quad 5 \quad K \\
&\quad J \quad 6 \\
&\quad K
\end{align*}
\]

14. \[
\begin{align*}
&\; L \quad 11 \\
&\quad J \quad 19 \\
&\quad K
\end{align*}
\]
10-8 Practice

Trigonometric Ratios

Find the values of the three trigonometric ratios for angle A.

1. \[
\begin{array}{c}
\text{B} \\
\text{C} \\
\text{A}
\end{array}
\]

2. \[
\begin{array}{c}
\text{A} \\
\text{B} \\
\text{C}
\end{array}
\]

Use a calculator to find the value of each trigonometric ratio to the nearest ten-thousandth.

3. \[\tan 26^\circ\]

4. \[\sin 53^\circ\]

5. \[\cos 81^\circ\]

Solve each right triangle. Round each side length to the nearest tenth.

6. \[
\begin{array}{c}
\text{C} \\
\text{A} \\
\text{B}
\end{array}
\]

7. \[
\begin{array}{c}
\text{B} \\
\text{A} \\
\text{C}
\end{array}
\]

Find \(m \angle J\) for each right triangle to the nearest degree.

8. \[
\begin{array}{c}
\text{L} \\
\text{J} \\
\text{K}
\end{array}
\]

9. \[
\begin{array}{c}
\text{J} \\
\text{L} \\
\text{K}
\end{array}
\]

10. SURVEYING If point A is 54 feet from the tree, and the angle between the ground at point A and the top of the tree is 25°, find the height \(h\) of the tree.
Word Problem Practice

Trigonometric Ratios

1. WASHINGTON MONUMENT Jeannie is trying to determine the height of the Washington Monument. If point $A$ is 765 feet from the monument, and the angle between the ground and the top of the monument at point $A$ is $36^\circ$, find the height $h$ of the monument to the nearest foot.

![Diagram of Washington Monument]

2. AIRPLANES A pilot takes off from a runway at an angle of $20^\circ$ and maintains that angle until it is at its cruising altitude of 2500 feet. What horizontal distance has the plane traveled when it reaches its cruising altitude?

3. TRUCK RAMPS A moving company uses an 11-foot-long ramp to unload furniture from a truck. If the bed of the truck is 3 feet above the ground, what is the angle of incline of the ramp to the nearest degree?

4. SPECIAL TRIANGLES While investigating right triangle $KLM$, Mercedes finds that $\cos M = \sin M$. What is the measure of angle $M$?

5. TELEVISIONS Televisions are commonly sized by measuring their diagonal. A common size for widescreen plasma TVs is 42 inches.

![Diagram of television]

a. A widescreen television has a 16:9 aspect ratio, that is, the screen width is $\frac{16}{9}$ times the screen height. Use the Pythagorean Theorem to write an equation and solve for the height $h$ of the television in inches.

b. Use the information from part a to solve the right triangle.

c. What would the measure of angle $A$ be on a standard television with a 4:3 aspect ratio?
In addition to the sine, cosine, and tangent, there are three other common trigonometric ratios. They are the secant, cosecant, and cotangent.

<table>
<thead>
<tr>
<th>Trigonometric Ratio</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secant of $\angle A$</td>
<td>$\frac{\text{hypotenuse}}{\text{leg opposite } \angle A}$</td>
</tr>
<tr>
<td>Secant of $\angle B$</td>
<td>$\frac{\text{hypotenuse}}{\text{leg opposite } \angle B}$</td>
</tr>
<tr>
<td>Cosecant of $\angle A$</td>
<td>$\frac{\text{hypotenuse}}{\text{leg adjacent } \angle A}$</td>
</tr>
<tr>
<td>Cosecant of $\angle B$</td>
<td>$\frac{\text{hypotenuse}}{\text{leg adjacent } \angle B}$</td>
</tr>
<tr>
<td>Cotangent of $\angle A$</td>
<td>$\frac{\text{leg adjacent to } \angle A}{\text{leg opposite } \angle A}$</td>
</tr>
<tr>
<td>Cotangent of $\angle B$</td>
<td>$\frac{\text{leg adjacent to } \angle B}{\text{leg opposite } \angle B}$</td>
</tr>
</tbody>
</table>

**Example**

Find the secant, cosecant, and cotangent of angle $A$.

Use the side lengths to write the trigonometric ratios.

- $\sec A = \frac{\text{hyp}}{\text{opp}} = \frac{15}{9} = \frac{5}{3}$
- $\csc A = \frac{\text{hyp}}{\text{adj}} = \frac{15}{12} = \frac{5}{4}$
- $\cot A = \frac{\text{adj}}{\text{opp}} = \frac{12}{9} = \frac{4}{3}$

**Exercises**

Find the secant, cosecant, and cotangent of angle $A$.

1. $\cdots$
2. $\cdots$
3. $\cdots$

4. How does the sine of an angle relate to the angle's cosecant? How does the cosine of an angle relate to the angle's secant? How does the cotangent of an angle relate to the angle's secant?

Use the relations that you found in Exercise 4 and a calculator to find the value of each trigonometric ratio to the nearest ten-thousandth.

5. $\sec 17^\circ$
6. $\csc 49^\circ$
7. $\cot 81^\circ$
Use this recording sheet with pages 664–665 of the Student Edition.

**Multiple Choice**

Read each question. Then fill in the correct answer.

1. ○ ○ ○ ○  
2. ○ ○ ○ ○  
3. ○ ○ ○ ○  
4. ○ ○ ○ ○  
5. ○ ○ ○ ○  
6. ○ ○ ○ ○  
7. ○ ○ ○ ○

**Short Response/Gridded Response**

Record your answer in the blank.

For gridded response questions, also enter your answer in the grid by writing each number or symbol in a box. Then fill in the corresponding circle for that number or symbol.

8. __________ (grid in)  
9. __________  
10. __________ (grid in)  
11. __________  
12. __________ (grid in)  
13. __________  
14. __________  
15. __________ (grid in)

**Extended Response**

Record your answers for Question 16 on the back of this paper.
Rubric for Scoring Extended Response

General Scoring Guidelines

• If a student gives only a correct numerical answer to a problem but does not show how he or she arrived at the answer, the student will be awarded only 1 credit. All extended response questions require the student to show work.

• A fully correct answer for a multiple-part question requires correct responses for all parts of the question. For example, if a question has three parts, the correct response to one or two parts of the question that required work to be shown is not considered a fully correct response.

• Students who use trial and error to solve a problem must show their method. Merely showing that the answer checks or is correct is not considered a complete response for full credit.

Exercise 16 Rubric

<table>
<thead>
<tr>
<th>Score</th>
<th>Specific Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>A correct solution that is supported by well-developed, accurate explanations. The distance between Karen’s school and the park is 25.1 miles. The coordinates of Karen’s house are (0.5, 0.5). The student should show a working knowledge of the Distance and Midpoint formulas.</td>
</tr>
<tr>
<td>3</td>
<td>A generally correct solution, but may contain minor flaws in reasoning or computation.</td>
</tr>
<tr>
<td>2</td>
<td>A partially correct interpretation and/or solution to the problem.</td>
</tr>
<tr>
<td>1</td>
<td>A correct solution with no evidence or explanation.</td>
</tr>
<tr>
<td>0</td>
<td>An incorrect solution indicating no mathematical understanding of the concept or task, or no solution is given.</td>
</tr>
</tbody>
</table>
Chapter 10 Quiz 1
(Lessons 10-1 and 10-2)

1. Graph \( y = 2\sqrt{x} + 1 \). State the domain and range.

2. MULTIPLE CHOICE Which expression has a domain of \( \{x \mid x \geq 4\} \)?
   A \( y = \sqrt{x} - 4 \) 
   B \( y = \sqrt{x} + 4 \) 
   C \( y = \sqrt[4]{x} - 4 \) 
   D \( y = \sqrt{x} + 4 \)

Simplify each expression.

3. \( \sqrt{72} \)

4. \( \sqrt{8x^2y} \)

5. \( \frac{3}{4 + \sqrt{2}} \)

Chapter 10 Quiz 2
(Lessons 10-3 and 10-4)

Simplify each expression.

1. \( 6\sqrt{45} + 2\sqrt{80} \)

2. \( 5\sqrt{6} - 4\sqrt{10} - \sqrt{6} + 12\sqrt{10} \)

3. \( \sqrt{10(\sqrt{5} + 3\sqrt{2})} \)

4. \( (\sqrt{6} - \sqrt{5})(\sqrt{10} + \sqrt{3}) \)

5. MULTIPLE CHOICE Find the perimeter of a rectangle with a width \( 2\sqrt{5} + 3\sqrt{11} \) and a length \( 3\sqrt{5} - \sqrt{11} \).
   A \( 7\sqrt{55} - 3 \) 
   B \( 5\sqrt{5} + 2\sqrt{11} \) 
   C \( 14\sqrt{55} - 6 \) 
   D \( 10\sqrt{5} + 4\sqrt{11} \)

Solve each equation. Check your solution.

6. \( \sqrt{2x + 6} + 6 = 10 \)

7. \( \sqrt{c + 2} = c - 4 \)

8. \( \sqrt{11x - 24} = x \)

9. \( 3\sqrt{(m + 5)} - 3 = 6 \)

10. \( \sqrt{3a + 4} = \sqrt{12a - 14} \)
1. If \( c \) is the measure of the hypotenuse of a right triangle, find the missing measure. If necessary, round to the nearest hundredth. \( b = 3, c = 15, a = ? \)

2. Determine whether the side measures 7, 9, and 12 form a right triangle.

3. **MULTIPLE CHOICE** What is the area of triangle \( MNP \)?
   - A 29.68 units\(^2\)
   - B 19.21 units\(^2\)
   - C 153.67 units\(^2\)
   - D 307.35 units\(^2\)

4. Find the distance between the points at \( (0, 7) \) and \( (-5, 13) \).

5. Find the coordinates of the midpoint of the segment with endpoints \( (-3, 11) \) and \( (-5, 5) \).

---

1. Determine whether the pair of triangles is similar. Justify your answer.

2. Find the measures of the missing sides if \( \triangle ABC \sim \triangle XYZ \).
   \( a = 9, c = 15, x = 6, y = 14 \)

3. **SHADOWS** If a 26-foot tree casts a shadow that is 14 feet long and a nearby tower casts a shadow that is 21 feet long, how tall is the tower?

4. **MULTIPLE CHOICE** Which is not equal to 1?
   - A \( \sin 45^\circ \)
   - B \( \tan 45^\circ \)
   - C \( \cos 0^\circ \)
   - D \( \sin 90^\circ \)

5. Solve the triangle. Round each side length to the nearest tenth.
Chapter 10 Mid-Chapter Test
(Lessons 10-1 through 10-4)

Part I Write the letter for the correct answer in the blank at the right of each question.

1. Which expression has a range of \( \{y \mid y \geq 2\}\)?
   
   \[ y = \sqrt{x - 2} \quad B \ y = \sqrt{x + 2} \quad C \ y = \sqrt{x - 2} \quad D \ y = \sqrt{x} + 2 \]
   
   1. _____

2. Which expression has a domain of \( \{x \mid x \geq 1\}\)?
   
   \[ F \ y = \sqrt{x - 1} \quad G \ y = \sqrt{x + 1} \quad H \ y = \sqrt{x} - 1 \quad J \ y = \sqrt{x} + 1 \]
   
   2. _____

For Questions 3–5, simplify each expression.

3. \( \sqrt{288} \)
   
   \[ A \ 4\sqrt{18} \quad B \ 2\sqrt{12} \quad C \ 4\sqrt{6} \quad D \ 12\sqrt{2} \]
   
   3. _____

4. \( \sqrt{20x^3y^2} \)
   
   \[ F \ 5x |y| 2\sqrt{x} \quad G \ 2x |y| \sqrt{5x} \quad H \ 2|x|y\sqrt{5x} \quad J \ 5|x|y\sqrt{2x} \]
   
   4. _____

5. \( \sqrt{\frac{t}{18}} \)
   
   \[ A \ \frac{\sqrt{t}}{3\sqrt{2}} \quad B \ \frac{|t|}{18} \quad C \ \frac{3t}{18} \quad D \ \frac{\sqrt{2t}}{6} \]
   
   5. _____

6. Solve \( \sqrt{5n - 1} - n = 1 \).
   
   \[ F \ 1, 2 \quad G \ -1, -2 \quad H \ \frac{1}{4} \quad J \ 1 \]
   
   6. _____

7. Solve \( \sqrt{(7 - 2b)} = \sqrt{(9 - b)} \)
   
   \[ A \ \frac{1}{2} \quad B \ 2 \quad C \ -\frac{1}{2} \quad D \ -2 \]
   
   7. _____

Part II

Simplify each expression.

8. \( \sqrt{15(2\sqrt{3} - 4\sqrt{5})} \)

9. \( (4\sqrt{3} + 5)(4\sqrt{3} - 5) \)

10. \( \sqrt{288} + 3\sqrt{162} \)

11. \( 6\sqrt{5} - 2\sqrt{10} + \sqrt{5} \)

12. \( 3\sqrt{50} - 2\sqrt{72} + \sqrt{24} \)

For Questions 13 and 14, solve each equation.

13. \( 2\sqrt{5x} - 3 = 7 \)

14. \( \sqrt{x - 4} = x - 24 \)

15. A square has an area of 90 square inches. The formula for the area \( A \) of a square with side length \( \ell \) is \( A = \ell^2 \).
   
   Find the length of one side of the square.

15. ________
Choose from the terms above to complete each sentence.

1. If you exchange the hypothesis and conclusion of an if-then statement, the result is the ______________ of the statement.

2. The trigonometric ratio equivalent to the leg adjacent to an angle divided by the hypotenuse is the ______________.

3. If a coordinate grid is superimposed on a map, you can find the distance between two places on the map using the ______________.

4. The equation $8 = 3\sqrt{d}$ is an example of a ______________.

5. The binomials $5\sqrt{3} + 2\sqrt{5}$ and $5\sqrt{3} - 2\sqrt{5}$ are ______________.

6. In a right triangle, the side opposite the right angle is the ______________.

7. The expression $7x$ under the radical symbol in $\sqrt{7x}$ is called the ______________.

8. The two sides of a right triangle that are not the hypotenuse are called ______________.

9. If two triangles have three pairs of corresponding angles with equal measures, the triangles are ______________.

Define each term in your own words.

10. trigonometry

11. tangent
Write the letter for the correct answer in the blank at the right of each question.

1. How does the graph of \( y = \sqrt{x} + 2 \) compare to the parent graph?
   A translated up 2  
   B translated down 2  
   C translated left 2  
   D translated right 2 
   \( \boxed{\text{1. } \_} \)

2. Which expression has a domain of \( \{x \mid x \geq -1\} \)?
   F \( y = \sqrt{x + 1} \),  
   G \( y = \sqrt{x - 1} \),  
   H \( y = \sqrt{x} + 1 \),  
   J \( y = \sqrt{x} - 1 \)  
   \( \boxed{\text{2. } \_} \)

For Questions 3–7, simplify each expression.

3. \( \sqrt{90} \)
   A 9\( \sqrt{10} \),  
   B 10\( \sqrt{9} \),  
   C 3\( \sqrt{10} \),  
   D \( \sqrt{30} \)  
   \( \boxed{\text{3. } \_} \)

4. \( \frac{3}{5 - \sqrt{2}} \)
   F \( \frac{15 + 3\sqrt{2}}{23} \),  
   G \( \frac{15 - 3\sqrt{2}}{23} \),  
   H \( 15 + 3\sqrt{2} \),  
   J \( \frac{15 + 3\sqrt{2}}{3} \)  
   \( \boxed{\text{4. } \_} \)

5. \( 6\sqrt{5} - 2\sqrt{5} \)
   A 4  
   B \(-12 \)  
   C \(-12\sqrt{5} \)  
   D \( 4\sqrt{5} \)  
   \( \boxed{\text{5. } \_} \)

6. \( 3\sqrt{12} + \sqrt{27} - 2\sqrt{20} \)
   F \( 14\sqrt{3} - 4\sqrt{5} \),  
   G \( 3\sqrt{3} - \sqrt{2} \),  
   H \( 9\sqrt{3} - 4\sqrt{5} \),  
   J \( 21\sqrt{3} - 8\sqrt{5} \)  
   \( \boxed{\text{6. } \_} \)

7. \( \sqrt{2}(\sqrt{6} + 3\sqrt{2}) \)
   A \( 3\sqrt{2} + 6 \),  
   B \( 6\sqrt{2} \),  
   C \( 2\sqrt{3} + 3\sqrt{2} \),  
   D \( 2\sqrt{3} + 6 \)  
   \( \boxed{\text{7. } \_} \)

8. Solve \( \sqrt{2x} - 5 = 3 \).
   F 4  
   G 7  
   H \(-8 \)  
   J \( \frac{11}{2} \)  
   \( \boxed{\text{8. } \_} \)

9. Solve \( \sqrt{2x} + 8 = x \).
   A \(-2, 4 \)  
   B 4  
   C \(-2 \)  
   D \( 2, 4 \)  
   \( \boxed{\text{9. } \_} \)

10. Find the length of the hypotenuse of a right triangle if \( a = 3 \) and \( b = 4 \).
    F 5  
    G \( \sqrt{7} \),  
    H 25  
    J 7  
    \( \boxed{\text{10. } \_} \)

11. Determine which side measures form a Pythagorean triple.
    A 4, 5, 6  
    B 3, 4, 5  
    C 5, 11, 12  
    D 4, 8, 12  
    \( \boxed{\text{11. } \_} \)

12. Find the coordinates of the midpoint of the segment with endpoints at \((1, 3)\) and \((9, 9)\).
    F \((4, 6)\)  
    G \((5, 6)\)  
    H \((8, 6)\)  
    J \((10, 12)\)  
    \( \boxed{\text{12. } \_} \)
13. Find the distance between the points at (0, 0) and (5, 12).
   A 17 B $\sqrt{17}$ C $\sqrt{60}$ D 13

14. Which pair of triangles is similar?
   F \hspace{1cm} G \hspace{1cm} H \hspace{1cm} J

15. If $\triangle ABC \sim \triangle DEF$, and $c = 8$, $f = 4$, and $b = 12$, find $e$.
   A 24 B 8 C 6 D $\frac{2\sqrt{3}}{3}$

16. What is the length of a diagonal of a rectangle with a length of 8 meters and a width of 6 meters?
   F 10 m G 14 m H 48 m J 100 m

17. Determine which side measures form a right triangle.
   A 10, 24, 28 B 13, 17, 21 C $\sqrt{3}, \sqrt{4}, \sqrt{5}$ D 5, 12, 13

18. SAILING A 12-foot cable attached to the top of the mast of a sailboat is fastened to a point on the deck 4 feet from the base of the mast. What is the height of the mast?
   F 9.56 ft G 22 ft H 11.31 ft J 128 ft

For Questions 19 and 20, the leg adjacent to $\angle A$ in a right triangle measures 8 units, and the hypotenuse measures 13 units.

19. What is $\cos A$?
   A $\frac{8}{13}$ B $\frac{13}{8}$ C 38° D 52°

20. What is $m\angle A$?
   F 1° G 32° H 38° J 52°

Bonus Simplify $\sqrt{4x^2 + 4x + 1}$. B: ________
Chapter 10 Test, Form 2A

Write the letter for the correct answer in the blank at the right of each question.

1. How does the graph of \( y = \sqrt{x + 3} \) compare to the parent graph?
   A translated up 3  
   B translated down 3  
   C translated right 3  
   D translated left 3  
   1. _____

2. Which expression has a domain of \( \{ x \mid x \geq 2 \} \)?
   F \( y = \sqrt{x + 2} \)  
   G \( y = \sqrt{x - 2} \)  
   H \( y = \sqrt{x + 2} \)  
   J \( y = \sqrt{x - 2} \)  
   2. _____

For Questions 3–7, simplify each expression.

3. \( 5\sqrt{3} \cdot 2\sqrt{21} \)
   A \( 70\sqrt{3} \)  
   B \( 10\sqrt{63} \)  
   C \( 49\sqrt{3} \)  
   D \( 30\sqrt{7} \)  
   3. _____

4. \( \sqrt{\frac{x^2}{12}} \)
   F \( \frac{x^2}{2\sqrt{3}} \)  
   G \( \frac{|x| \sqrt{3}}{6} \)  
   H \( \frac{x}{6} \)  
   J \( \frac{|x|}{\sqrt{12}} \)  
   4. _____

5. \( \frac{5}{\sqrt{11} - \sqrt{6}} \)
   A \( 1 \)  
   B \( \frac{5\sqrt{66}}{66} \)  
   C \( \sqrt{11} + \sqrt{6} \)  
   D \( \frac{5\sqrt{11} + 5\sqrt{6}}{17} \)  
   5. _____

6. \( \sqrt{18} - \sqrt{54} + 2\sqrt{50} \)
   F \( 13\sqrt{2} - 3\sqrt{6} \)  
   G \( -4\sqrt{3} + 4\sqrt{5} \)  
   H \( -4\sqrt{3} - 4\sqrt{5} \)  
   J \( 8\sqrt{2} - 3\sqrt{6} \)  
   6. _____

7. \( (\sqrt{14} + 3)(\sqrt{6} - \sqrt{7}) \)
   A \( 2\sqrt{5} - \sqrt{21} + 3 - \sqrt{10} \)  
   B \( \sqrt{21} - 4\sqrt{2} \)  
   C \( \sqrt{21} \)  
   D \( \sqrt{21} + \sqrt{2} \)  
   7. _____

8. Solve \( \sqrt{3x - 2} + 4 = 8 \).
   F \( 12 \)  
   G \( 6 \)  
   H \( \frac{2}{3} \)  
   J \( \frac{3}{2} \)  
   8. _____

9. Solve \( \sqrt{7a + 32} = a + 2 \).
   A \( -4 \)  
   B \( 7 \)  
   C \( -4, 7 \)  
   D \( -7, 4 \)  
   9. _____

10. A right triangle has one leg that is 7 centimeters. The hypotenuse is 25 centimeters. Find the length of the other leg.
    F \( 15 \text{ cm} \)  
    G \( \sqrt{674} \text{ cm} \)  
    H \( 24 \text{ cm} \)  
    J \( 5\sqrt{7} \text{ cm} \)  
    10. _____

11. Determine which side measures form a right triangle.
    A \( 3, 8, 12 \)  
    B \( 5, 9, 11 \)  
    C \( 11, 13, 16 \)  
    D \( 6, 8, 10 \)  
    11. _____

12. Find the distance between the points at \((-3, 4)\) and \((2, 7)\).
    F \( \sqrt{34} \)  
    G \( \sqrt{74} \)  
    H \( 2\sqrt{30} \)  
    J \( \sqrt{10} \)  
    12. _____
13. Find the coordinates of the midpoint of the segment with endpoints at the origin and (−6, 8).

A (−12, 16)  B (−3, 4)  C (3,−4)  D (6, −8)  13. _____

14. Which pair of triangles is similar?

F  

G  

H  

J  14. _____

15. If \( \triangle ABC \sim \triangle DEF \), and \( a = 10 \), \( b = 12 \), \( d = 6 \), and \( f = 6.6 \), find the measures of the missing sides.

A \( c = 11, e = 7.2 \)  B \( c = 7.3, e = 10.9 \)

C \( c = 4, e = 20 \)  D \( c = 6.6, e = 8.9 \)  15. _____

16. What is the length of a diagonal of a rectangle with a length of 9 inches and a width of 3 inches?

F 3.5 in.  G 9.5 in.  H 18 in.  J 90 in.  16. _____

17. Determine which side measures form a right triangle.

A 1, 2, 3  B 2, 3, 4  C 3, 4, 5  D 4, 5, 6  17. _____

18. **LADDERS** A 16 foot ladder leans against a wall. The base of the ladder is 6 feet from where the wall meets the ground. How far up the wall does the ladder reach?

F 14.8 ft  G 12.9 ft  H 144 ft  J 220 ft  18. _____

For Questions 19 and 20, the leg opposite to \( \angle A \) in a right triangle measures 12 units, and the hypotenuse measures 19 units.

19. What is \( \sin A \)?

A \( \frac{12}{19} \)  B \( \frac{19}{12} \)  C 0.775  D 0.815  19. _____

20. What is \( m\angle A \)?

F 0.01°  G 32°  H 39°  J 51°  20. _____

**Bonus** Find the length of a diagonal of a square if its area is 72 square meters.

B: __________
Chapter 10 Test, Form 2B

Write the letter for the correct answer in the blank at the right of each question.

1. How does the graph of \( y = \sqrt{x - 8} \) compare to the parent graph?
   - A translated up 8
   - B translated down 8
   - C translated left 8
   - D translated right 8

2. Which expression has a range of \( \{y \mid y \geq 1\} \)?
   - F \( y = \sqrt{x} + 1 \)
   - G \( y = \sqrt{x} - 1 \)
   - H \( y = \sqrt{x + 1} \)
   - J \( \sqrt{x - 1} \)

For Questions 3–7, simplify each expression.

3. \( 3\sqrt{6} \cdot 5\sqrt{2} \)
   - A \( 24\sqrt{2} \)
   - B \( 30\sqrt{3} \)
   - C \( 45\sqrt{2} \)
   - D \( 15\sqrt{12} \)

4. \( \sqrt{\frac{18}{y}} \)
   - F \( \frac{3\sqrt{2y}}{y} \)
   - G \( 3\sqrt{\frac{2}{y}} \)
   - H \( \frac{6}{y} \)
   - J \( 3\sqrt{\frac{2}{y}} \)

5. \( \frac{3}{\sqrt{8} + \sqrt{5}} \)
   - A \( 1 \)
   - B \( \frac{3\sqrt{40}}{40} \)
   - C \( 2\sqrt{2} - \sqrt{5} \)
   - D \( \frac{6\sqrt{2} - 3\sqrt{5}}{13} \)

6. \( 3\sqrt{32} - 2\sqrt{18} + \sqrt{54} \)
   - F \( 4\sqrt{2} - 3\sqrt{6} \)
   - G \( 2\sqrt{6} + 6\sqrt{3} \)
   - H \( 2\sqrt{6} - 6\sqrt{3} \)
   - J \( 6\sqrt{2} + 3\sqrt{6} \)

7. \( (\sqrt{7} - \sqrt{10})(\sqrt{5} + \sqrt{14}) \)
   - A \( 2\sqrt{3} + \sqrt{21} - \sqrt{15} - 2\sqrt{6} \)
   - B \( -\sqrt{35} \)
   - C \( 2\sqrt{2} - \sqrt{35} \)
   - D \( 12\sqrt{2} + 3\sqrt{35} \)

8. Solve \( \sqrt{3x} + 1 + 3 = 7 \).
   - F \( 13 \)
   - G \( \frac{1}{3} \)
   - H \( -1, \frac{1}{3} \)
   - J \( 5 \)

9. Solve \( \sqrt{5x} + 39 = x + 3 \).
   - A \( -6, 5 \)
   - B \( -6 \)
   - C \( 5 \)
   - D \( -5, 6 \)

10. A right triangle has one leg that is 8 inches. The hypotenuse is 17 inches. Find the length of the other leg.
    - F \( 15 \text{ in.} \)
    - G \( \sqrt{353} \text{ in.} \)
    - H \( 9 \text{ in.} \)
    - J \( 2\sqrt{34} \text{ in.} \)

11. Determine which side measures form a right triangle.
    - A \( 4, 7, 8 \)
    - B \( 9, 12, 15 \)
    - C \( 3, 7, 9 \)
    - D \( 10, 15, 20 \)

12. Find the distance between the points at \((-2, 7)\) and \((-3, -4)\).
    - F \( \sqrt{29} \)
    - G \( \sqrt{82} \)
    - H \( \sqrt{34} \)
    - J \( \sqrt{122} \)
13. Find the coordinates of the midpoint of the segment with endpoints at the origin and \((-6, 4)\).
   - A \((-12, 8)\)
   - B \((-3, 2)\)
   - C \((3, -2)\)
   - D \((6, -4)\)

14. Which pair of triangles is similar?
   - F
   - H
   - G
   - J

15. If \(\triangle ABC \sim \triangle ABC\), and \(a = 10\), \(c = 12\), \(d = 9\), and \(e = 7.2\), find the measures of the missing sides.
   - A \(b = 6.5, f = 13.3\)
   - B \(b = 6, f = 11.5\)
   - C \(b = 12.5, f = 7.5\)
   - D \(b = 8, f = 10.8\)

16. What is the length of a diagonal of a rectangle with a length of 14 inches and a width of 7 inches?
   - F 9.4 in.
   - G 15.7 in.
   - H 49 in.
   - J 245 in.

17. Determine which side measures form a right triangle.
   - A 5, 12, 13
   - B 6, 13, 14
   - C 7, 14, 15
   - D 8, 15, 16

18. LADDERS A 24-foot ladder leans against a wall. The base of the ladder is 9 feet from where the wall meets the ground. How far up the wall does the ladder reach?
   - F 495 ft
   - G 20.9 ft
   - H 81 ft
   - J 22.2 ft

For Questions 19 and 20, the leg opposite to \(\angle B\) in a right triangle measures 15 units, and the hypotenuse measures 28 units.

19. What is \(\sin A\)?
   - A \(\frac{15}{28}\)
   - B \(\frac{28}{15}\)
   - C 0.634
   - D 0.844

20. What is \(m\angle A\)?
   - F 0.01°
   - G 28°
   - H 32°
   - J 58°

Bonus Find the length of a diagonal of a square if its area is 98 square feet.
1. Graph \( y = \sqrt{x - 2} + 1 \) and compare to the parent graph. State the domain and range.

2. State the domain and range of \( y = -3\sqrt{x - 1} + 5 \).

For Questions 3–7, simplify each expression.

3. \( \sqrt{24} \cdot \sqrt{3} \)

4. \( \sqrt{75y^4w^3} \)

5. \( \frac{2\sqrt{3}}{\sqrt{6} - 2} \)

6. \( \sqrt{20} + 2\sqrt{45} + 3\sqrt{80} \)

7. \( (\sqrt{6} + \sqrt{7})(\sqrt{21} - \sqrt{2}) \)

Solve each equation. Check your solution.

8. \( \sqrt{m} = 2\sqrt{3} \)

9. \( \sqrt{2a + 14} - 13 = -7 \)

10. \( 10 + \sqrt{x - 8} = x \)

If \( c \) is the measure of the hypotenuse of a right triangle, find each missing measure. If necessary, round to the nearest hundredth.

11. \( a = 6, \ b = 10, \ c = ? \)

12. \( b = 24, \ c = 25, \ a = ? \)

Determine whether the following side measures form right triangles.

13. \( 14, 48, 50 \)

14. \( 12, 24, 36 \)

For Questions 15 and 16, find the distance between each pair of points whose coordinates are given. Express answers in simplest radical form and as decimal approximations rounded to the nearest hundredth, if necessary.

15. \( (0, -4), (5, 2) \)

16. \( (7, 3), (-4, 11) \)

17. Find the coordinates of the midpoint of the segment with endpoints \( (3, -2) \) and \( (-5, 6) \).
For Questions 18 and 19, determine whether each pair of triangles is similar. Justify your answer.

18. \[ \triangle ABC \sim \triangle XYZ \]

19. \[ \triangle DEF \sim \triangle GHI \]

20. Find the measures of the missing sides for the set of measures given if \( \triangle MET \sim \triangle CUB \).
   \[ b = 2, \ e = 9, \ m = 7, \ t = 3 \]

21. Find the height of the tree.

   \[ \text{Tree} \]
   \[ \text{Height} = \text{Base} \times \tan(\theta) \]

22. A boat leaves the harbor and sails 7 miles west and 2 miles north to an island. The next day it travels to a second island 5 miles south and 3 miles east of the harbor. How far is it from the first island to the second island?

23. What is the length of a rectangle if the width is 10 cm and the diagonal is 16 cm?

24. Solve \( m \angle J \) for the right triangle to the nearest degree.

25. At a loading dock, a ramp is 55 feet long. The angle the ramp makes with the ground is 25°. Find the height reached by the ramp.

Bonus Solve \( 8 - 3x = \sqrt{4x^2 + 20} + 8 \).
1. Graph \( y = \sqrt{x + 1} - 3 \) and compare to the parent graph. State the domain and range.

2. State the domain and range of \( y = -2\sqrt{x + 2} - 1 \).

Simplify each expression.

3. \( \sqrt{40} \cdot \sqrt{5} \)

4. \( \sqrt{50x^2y^2} \)

5. \( \frac{5\sqrt{2}}{\sqrt{10} - 3} \)

6. \( 2\sqrt{24} + \sqrt{54} + 3\sqrt{150} \)

7. \( (\sqrt{11} - \sqrt{6})(\sqrt{2} + \sqrt{33}) \)

Solve each equation. Check your solution.

8. \( \sqrt{7x} - 3 = 5 \)

9. \( \sqrt{\frac{4x}{3}} - 2 = 0 \)

10. \( x + 3 = \sqrt{3x} + 37 \)

If \( c \) is the measure of the hypotenuse of a right triangle, find each missing measure. If necessary, round to the nearest hundredth.

11. \( a = 4, b = 7, c = ? \)  
12. \( b = 15, c = 17, a = ? \)

Determine whether the following side measures form right triangles.

13. 15, 20, 25  
14. 16, 20, 30

Find the distance between each pair of points whose coordinates are given. Express answers in simplest radical form and as decimal approximations rounded to the nearest hundredth, if necessary.

15. \( (-3, 0), (2, 7) \)  
16. \( (5, 8), (-7, 1) \)

17. Find the coordinates of the midpoint of the segment with endpoints \((7, -1)\) and \((-1, 5)\).
For Questions 18 and 19, determine whether each pair of triangles is similar. Justify your answer.

18. \[ \triangle ABC \sim \triangle XYZ \]

19. \[ \triangle ABC \sim \triangle XYZ \]

20. Find the measures of the missing sides for the set of measures given if \( \triangle ABC \sim \triangle XYZ \).
   \[ b = 15, \quad c = 9, \quad x = 9, \quad z = 6 \]

21. Find the height of the lamppost.

22. Mandy leaves her home for a walk. How far is she from her home after walking 2 miles due east and then 5 miles due south?

23. What is the width of a rectangle if the length is 13 cm and the diagonal is 20 cm?

24. Solve \( m \angle J \) for the right triangle to the nearest degree.

25. At a loading dock, a ramp is 80 feet long. The angle the ramp makes with the ground is 22°. Find the height reached by the ramp.

Bonus \( 12 + \sqrt{5x^2 + 36} = 12 - 3x \).
1. Graph \( y = -2\sqrt{x - 2} - 2 \) and compare to the parent graph. State the domain and range.

2. State the domain and range of \( y = -8\sqrt{x + 4} - 12 \).

Simplify each expression.

3. \( \sqrt{378} \cdot \sqrt{6} \)

4. \( \sqrt{\frac{5x^4}{4n^5}} \)

5. \( \frac{\sqrt{8}}{2\sqrt{5} + \sqrt{6}} \)

6. \( 5\sqrt{12} + 6\sqrt{\frac{1}{3}} - 3\sqrt{48} \)

7. \( (2\sqrt{6} + 7\sqrt{5})(2\sqrt{10} - 5\sqrt{3}) \)

For Questions 8–10, solve each equation. If necessary, leave in simplest radical form.

8. \( \sqrt{3n} - 2 + 6 = 10 \)

9. \( \sqrt{\frac{5n}{3}} + 12 = 7 \)

10. \( 2x = 6 + \sqrt{2x^2 - 7x + 1} \)

11. Find the length of the hypotenuse of a right triangle if \( a = \sqrt{5} \) and \( b = 6 \).

12. Find the width of a rectangle with a diagonal of 12 centimeters and a length of 10 centimeters.

For Questions 13 and 14, determine whether the following side measures form right triangles.

13. 16, 49, 65

14. 5, 9, \( \sqrt{106} \)

15. Find the distance between the points at \((-4, 6)\) and \((10, 13)\).

16. Find the value of \( a \) if the midpoint of the segment with endpoints \((3, a)\) and \(\left(\frac{a}{2}, 10\right)\) is \((2.5, 7)\).

17. Find the perimeter of a square \(ABCD\) if two of the vertices are \(A(8, -14)\) and \(B(3, -4)\).
For Questions 18 and 19, determine whether each pair of triangles is similar. Justify your answer.

18. \[
\begin{align*}
50^\circ & \quad 50^\circ \quad 45^\circ \\
\end{align*}
\]
19. \[
\begin{align*}
60^\circ & \quad 30^\circ & \quad 2x^\circ \\
x^\circ & \quad x^\circ \\
\end{align*}
\]

20. Find the measures of the missing sides for the set of measures given if \(\triangle XYZ \sim \triangle ABC\).
\[
\begin{align*}
a &= 2.4, \\
c &= 1.02, \\
x &= 12.6, \\
y &= 8.4
\end{align*}
\]

21. Find the distance across the lake from point A to point B, if \(\triangle ABC \sim \triangle EDC\).

22. A diagonal of a rectangle measures 15 cm. The length of the rectangle is 11 cm. What is the height of the rectangle?

23. Hubert left his home heading due east. He walked that way for 4 miles then headed due north for 7 miles. How far away is Hubert from his home?

24. Solve \(m \angle J\) for the right triangle to the nearest degree.

25. A freeway on-ramp is 625 feet long. The angle the ramp makes with the ground is 8°. Find the height reached by the on-ramp.

**Bonus** Simplify \(\frac{2\sqrt{6} - \sqrt{5}}{\sqrt{6} + 3\sqrt{5}}\).

\(B:\)
Chapter 10 Extended-Response Test

Demonstrate your knowledge by giving a clear, concise solution to each problem. Be sure to include all relevant drawings and justify your answers. You may show your solution in more than one way or investigate beyond the requirements of the problem.

1. The Product Property of Square Roots and the Quotient Property of Square Roots can be written in symbols as \( \sqrt{ab} = \sqrt{a} \cdot \sqrt{b} \)
   and \( \sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}} \), respectively.
   a. Explain the Product Property of Square Roots and discuss any limitations of \( a \) and \( b \) for this property.
   b. Explain the Quotient Property of Square Roots and discuss any limitations of \( a \) and \( b \) for this property.
   c. Discuss any similarities of the two properties.

2. The formula \( L = \sqrt{kP} \) represents the relationship between an airplane’s length \( L \) in feet and the pounds \( P \) its wings can lift, where \( k \) is a constant of proportionality calculated for each particular plane.
   a. Solve the formula for \( P \).
   b. For \( k = 0.12 \), choose three values for \( L \) and calculate the takeoff weight \( P \) for each value.
   c. For \( k = 0.08 \), choose three values for \( L \) and calculate the takeoff weight \( P \) for each value.
   d. Determine whether a larger or smaller constant of proportionality allows a plane to carry more weight.

3. a. Yoki claims that two triangles with two pairs of corresponding angles equal in measure are similar. Do you agree or disagree? Justify your reasoning.
   b. Yoki also claims that two triangles with two pairs of sides equal in measure are similar. Do you agree or disagree? Justify your reasoning.

4. a. Choose values for \( a \) and \( b \), then find the distance between each pair of points.
   b. Show that the triangle is a right triangle by using the Pythagorean Theorem.
10 Standardized Test Practice
(Chapters 1–10)

Part 1: Multiple Choice

Instructions: Fill in the appropriate circle for the best answer.

1. Simplify \((mt^2)(m^3)(m^2t)\). (Lesson 8-1)
   - A \(m^6t^3\)
   - B \(m^6t^2\)
   - C \(m^8t^2\)
   - D \(m^3t^2\)
   1. 0 0 0 0

2. Find \((x + 2y)^2\). (Lesson 7-8)
   - F \(x^2 + 2xy + 2y^2\)
   - H \(x^2 + 4xy + 4y^2\)
   - G \(x^2 + 4y^2\)
   - J \(2x^2 + 2xy + 4y^2\)
   2. 0 0 0 0

3. Solve \(6r^2 - 14r - 15 = 0\) by using the Quadratic Formula. Round to the nearest tenth. (Lesson 9-5)
   - A \(\emptyset\)
   - B \(-3.1, 0.8\)
   - C \(-0.8, 3.1\)
   - D \(0.8, 3.1\)
   3. 0 0 0 0

4. Which binomial is a factor of \(15t^2 - t - 6\)? (Lesson 8-4)
   - F \(3t - 2\)
   - G \(5t - 3\)
   - H \(3t + 1\)
   - J \(5t - 6\)
   4. 0 0 0 0

5. Use the graph to identify two consecutive integers between which a root lies. (Lesson 9-2)
   - A 1, 2
   - B -4, -3
   - C -3, -2
   - D -2, -1
   5. 0 0 0 0

6. Solve \(x^2 - 14x + 49 = 64\). (Lesson 8-6)
   - F \(\{6, 22\}\)
   - G \(\{-1, 15\}\)
   - H \(\{-15, 1\}\)
   - J \(\{-1, 1\}\)
   6. 0 0 0 0

7. Determine the amount of an investment if $800 is invested at an interest rate of 6.5% compounded monthly for 5 years. (Lesson 9-8)
   - A $15,223.65
   - B $34,999.87
   - C $1096
   - D $1106.25
   7. 0 0 0 0

8. Which expression cannot be simplified? (Lesson 10-3)
   - F \(5\sqrt{8} + 2\sqrt{18}\)
   - G \(3\sqrt{55} - 4\sqrt{65}\)
   - H \(2\sqrt{112} + \sqrt{63}\)
   - J \(2\sqrt{45} + 4\sqrt{20}\)
   8. 0 0 0 0

9. Find the length of the hypotenuse of a right triangle if \(a = 21\) and \(b = 20\). (Lesson 10-5)
   - A 6.4
   - B 841
   - C 29
   - D 41
   9. 0 0 0 0

10. Find the value of \(a\) if the distance between the points at \((-6, 5)\) and \((a, -7)\) is 13 units. (Lesson 10-6)
    - F \(-11\) or \(-1\)
    - G \(-9.6\) or \(-2.4\)
    - H 11 or 1
    - J 9.6 or 2.4
   10. 0 0 0 0

11. If a 10-foot lightpole casts a 12-foot-long shadow and the nearby library casts a 42-foot-long shadow, how high is the library? (Lesson 10-7)
    - A 35 ft
    - B 50.4 ft
    - C 28 ft
    - D 40 ft
   11. 0 0 0 0
12. What is the equation of the line that passes through (3, 2) and (0, −5)? (Lesson 4-2)
   \[ F \quad y = \left(\frac{3}{7}\right)x - 5 \]
   \[ G \quad y = -\left(\frac{7}{3}\right)x + 5 \]
   \[ H \quad y = -\left(\frac{3}{7}\right)x + 5 \]
   \[ J \quad y = \left(\frac{7}{3}\right)x - 5 \]

13. Find the slope of the line that passes through (5, 6) and (2, 1). (Lesson 3-3)
   \[ A \quad \frac{5}{3} \]
   \[ B \quad \frac{5}{3} \]
   \[ C \quad \frac{3}{5} \]
   \[ D \quad \frac{3}{5} \]

14. What is the length of a diagonal of a rectangle with a length of 10 inches and a width of 6 inches? (Lesson 10-5)
   \[ F \quad 4 \text{ in.} \]
   \[ G \quad 16 \text{ in.} \]
   \[ H \quad 11.7 \text{ in.} \]
   \[ J \quad 136 \text{ in.} \]

15. Solve the proportion \( \frac{b}{12} = \frac{10}{15} \). (Lesson 2-6)
   \[ A \quad 6 \]
   \[ B \quad 8 \]
   \[ C \quad 4 \]
   \[ D \quad 120 \]

16. Jackson’s meal cost $33.40. How much money should he leave for a 15% tip? (Lesson 2-7)
   \[ F \quad \text{about$2.00} \]
   \[ G \quad \text{about$3.00} \]
   \[ H \quad \text{about$4.00} \]
   \[ J \quad \text{about$5.00} \]

17. What is the length of a diagonal of a square with an area of 36 inches? (Lesson 10-5)
   \[ A \quad 9.4 \text{ in.} \]
   \[ B \quad 8.5 \text{ in.} \]
   \[ C \quad 72 \text{ in.} \]
   \[ D \quad 36 \text{ in.} \]

**Part 2: Gridded Response**

Instructions: Enter your answer by writing each digit of the answer in a column box and then shading in the appropriate circle that corresponds to that entry.

18. Find the discounted price.
   cookbook: $28
   discount: 65% (Lesson 2-7)

19. The basic breaking strength \( b \) in pounds for a natural fiber line is determined by the formula \( 900c^2 = b \), where \( c \) is the circumference of the line in inches. What circumference in inches of natural line would have 22,500 pounds of breaking strength? (Lesson 8-5)
20. **INVESTMENTS** Phyllis invested $12,000, part at 14% annual interest and the remainder at 10%. Last year she earned $1632 in interest. How much money did she invest at each rate? (Lesson 2-9)

21. Write an equation of a line whose slope is $-5$ and whose $y$-intercept is 14. (Lesson 4-1)

22. Solve $4 + w \leq 3$ or $5w - 14 > -4$. Then graph the solution set. (Lesson 5-4)

23. Use a graph to determine whether the system has no solution, one solution, or infinitely many solutions. $2y - x = 1$ and $2y - x = -2$ (Lesson 6-1)

24. **MANUFACTURING** A toy manufacturer makes two type of model airplanes, jets and biplanes. Each month they can make at most 120 planes. Each jet takes 2 hours to build and each biplane takes 5 hours to build. They use 500 hours or less each month to build model airplanes. Make a graph showing the number of jets and biplanes that can be made each month. (Lesson 5-6)

25. Simplify $\frac{21hk^3j^2}{-14h^{-3}kj^3}$. Assume that the denominator does not equal zero. (Lesson 7-2)

26. Find the GCF of $18a^2bc^3$ and $54ab^3c^2$. (Lesson 8-1)

27. Find two consecutive odd integers whose product is 255. (Lesson 8-3)

28. Solve $x^2 + 16x + 64 = 13$ by taking the square root of each side. Round to the nearest tenth, if necessary. (Lesson 9-4)

29. A conveyer valued at $12,000 depreciates at a steady rate of 18% per year. What is the value of the conveyer in 6 years? (Lesson 9-8)

30. Matt leaves his house to visit some friends. He drives 11 miles due west and then 9 miles due north to get to Joe’s house. He visits for a while and then drives 6 miles due south and 4 miles due west to get to Mason’s house. (Lesson 10-6)

   a. When Matt is at Joe’s house, how far is he from home?

   b. When Matt is at Mason’s house, how far is he from Joe’s house?
### Anticipation Guide

#### Radical Expressions and Triangles

**Step 1** Before you begin Chapter 10

- Read each statement.
- Decide whether you Agree (A) or Disagree (D) with the statement.
- Write A or D in the first column OR if you are not sure whether you agree or disagree, write NS (Not Sure).

<table>
<thead>
<tr>
<th>STEP 1</th>
<th>A, D, or NS</th>
<th>Statement</th>
<th>STEP 2</th>
<th>A or D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td>1. An expression that contains a square root is called a radical expression.</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td>2. It is always true that ( \sqrt{x} ) will equal ( \sqrt{a} \cdot \sqrt{b} ).</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td>3. ( \frac{1}{\sqrt{3}} ) is in simplest form because ( \sqrt{3} ) is not a whole number.</td>
<td></td>
<td>D</td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td>4. The sum of ( 3\sqrt{3} ) and ( 2\sqrt{3} ) will equal ( 5\sqrt{3} ).</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td>5. Before multiplying two radical expressions with different radicands the square roots must be evaluated.</td>
<td></td>
<td>D</td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td>6. When solving radical equations by squaring each side of the equation, it is possible to obtain solutions that are not solutions to the original equation.</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td>7. The longest side of any triangle is called the hypotenuse.</td>
<td></td>
<td>D</td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td>8. Because ( 5^2 = 4^2 + 3^2 ), a triangle whose sides have lengths 3, 4, and 5 will be a right triangle.</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td>9. On a coordinate plane, the distance between any two points can be found using the Pythagorean Theorem.</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td>10. The Distance Formula cannot be used to find the distance between two points on the same vertical line.</td>
<td></td>
<td>D</td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td>11. Two triangles are similar only if their corresponding angles are congruent and the measures of their corresponding sides are in proportion.</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td>12. All right triangles are similar.</td>
<td></td>
<td>D</td>
</tr>
</tbody>
</table>

**Step 2** After you complete Chapter 10

- Reread each statement and complete the last column by entering an A or a D.
- Did any of your opinions about the statements change from the first column?
- For those statements that you mark with a D, use a piece of paper to write an example of why you disagree.

#### Square Root Functions

**Dilations of Radical Functions** A square root function contains the square root of a variable. Square root functions are a type of radical function.

In order for a square root to be a real number, the radicand, or the expression under the radical sign, cannot be negative. Values that make the radicant negative are not included in the domain.

**Example**

Graph \( y = 3\sqrt{x} \). State the domain and range.

**Step 1** Make a table. Choose nonnegative values for \( x \).

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.5</td>
<td>2.12</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>4.24</td>
</tr>
<tr>
<td>4</td>
<td>7.36</td>
</tr>
</tbody>
</table>

**Step 2** Plot points and draw a smooth curve.

The domain is \( \{x | x \geq 0\} \) and the range is \( \{y | y \geq 0\} \).

#### Exercises

Graph each function, and compare to the parent graph. State the domain and range.

1. \( y = \frac{3}{2} \sqrt{x} \)
2. \( y = 4\sqrt{x} \)
3. \( y = \frac{2}{3} \sqrt{x} \)

**Dilation of** \( y = \sqrt{x} \): \( D = \{x | x \geq 0\}; \ R = \{y | y \geq 0\} \)

**Dilation of** \( y = 2\sqrt{x} \): \( D = \{x | x \geq 0\}; \ R = \{y | y \geq 0\} \)

**Dilation of** \( y = \frac{2}{3} \sqrt{x} \): \( D = \{x | x \geq 0\}; \ R = \{y | y \geq 0\} \)
Reflections and Translations of Radical Functions

Radical functions, like quadratic functions, can be translated horizontally and vertically, as well as reflected across the x-axis. To draw the graph of \( y = a \sqrt{x} + h \), follow these steps.

**Example**

Graph \( y = -\sqrt{x} + 1 \) and compare to the parent graph. State the domain and range.

**Step 1**

Make a table of values.

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-1)</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>-1</td>
</tr>
<tr>
<td>1</td>
<td>-1.41</td>
</tr>
<tr>
<td>2</td>
<td>-2</td>
</tr>
<tr>
<td>3</td>
<td>-3</td>
</tr>
</tbody>
</table>

**Step 2**

This is a horizontal translation 1 unit to the left of the parent function and reflected across the x-axis. The domain is \( \{x | x \geq 0\} \) and the range is \( \{y | y \leq 0\} \).

**Exercises**

Graph each function, and compare to the parent graph. State the domain and range.

1. \( y = \sqrt{x} + 3 \)
2. \( y = \sqrt{x} - 1 \)
3. \( y = -\sqrt{x} - 1 \)
4. \( y = \sqrt{x} + 1 \)
5. \( y = \sqrt{x} - 4 \)
6. \( y = \sqrt{x} - 1 \)
7. \( y = -\sqrt{x} - 3 \)
8. \( y = \sqrt{x} - 2 + 3 \)
9. \( y = -\frac{1}{2} \sqrt{x} - 4 + 1 \)
1. $y = \frac{4}{3} \sqrt{x}$
   - dilation of $y = \sqrt{x}$; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \geq 0\}$
   - translation of $y = \sqrt{x}$; up 2 units; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \geq 2\}$
   - translation of $y = \sqrt{x}$; left 3 units; $D = \{x \mid x \geq -3\}$, $R = \{y \mid y \geq 0\}$

2. $y = \sqrt{x} + 2$
   - translation of $y = \sqrt{x}$; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \geq 2\}$
   - translation of $y = \sqrt{x}$; up 2 units and right 1 unit; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \geq 1\}$
   - translation of $y = \sqrt{x}$; up 2 units and right 2 units, reflected in the x-axis; $D = \{x \mid x \geq 2\}$, $R = \{y \mid y \geq 1\}$

3. $y = \sqrt{x} - 3$
   - translation of $y = \sqrt{x}$; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \geq 0\}$
   - translation of $y = \sqrt{x}$; up 1 unit reflected in the x-axis; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \leq 1\}$
   - translation of $y = \sqrt{x}$; translated up 1 unit; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \geq 0\}$
   - translation of $y = \sqrt{x}$; translated up 1 unit and right 1 unit; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \geq 1\}$

4. $y = -\sqrt{x} + 1$
   - translation of $y = \sqrt{x}$; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \leq 1\}$
   - translation of $y = \sqrt{x}$; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \leq 0\}$
   - translation of $y = \sqrt{x}$; $D = \{x \mid x \geq 0\}$, $R = \{y \mid y \leq 2\}$

5. $y = 2 \sqrt{x} - 1 + 1$

6. $y = -\sqrt{x} - 2 + 2$

7. OHM'S LAW In electrical engineering, the resistance of a circuit can be found by the equation $I = \frac{V}{R}$, where $I$ is the current in amperes, $P$ is the power in watts, and $R$ is the resistance of the circuit in ohms. Graph this function for a circuit with a resistance of 4 ohms.

---

1. PENDULUM MOTION The period $T$ of a pendulum in seconds, which is the time for the pendulum to return to the point of release, is given by the equation $T = 1.11 \sqrt{L}$. The length of the pendulum in feet is given by $L$. Graph this function.

2. EMPIRE STATE BUILDING The roof of the Empire State Building is 1250 feet above the ground. The velocity of an object dropped from a height of $h$ meters is given by the function $V = \sqrt{2gh}$, where $g$ is the gravitational constant, 32.2 feet per second squared. If an object is dropped from the roof of the building, how fast is it traveling when it hits the street below?

   - approximately 284 ft/s

3. ERROR ANALYSIS Gregory is drawing the graph of $y = -5\sqrt{x} + 1$. He describes the range and domain as $x \geq -1$, $y \geq 0$. Explain and correct the mistake that Gregory made.

   - The domain is actually $x \leq 0$ because the graph has been reflected across the x-axis.

4. CAPACITORS A capacitor is a set of plates that can store energy in an electric field. The voltage $V$ required to store $E$ joules of energy in a capacitor with a capacitance of $C$ farads is given by $V = \frac{\sqrt{E}}{C}$.

   - a. Rewrite and simplify the equation for the case of a 0.0002 farad capacitor.

     - $V = 100 \sqrt{E}$

   - b. Graph the equation you found in part a.

   - c. How would the graph differ if you wished to store $E + 1$ joules of energy in the capacitor instead?

     - translation of $V = 100 \sqrt{E}$ one unit up to the left

   - d. How would the graph differ if you applied a voltage of $V + 1$ volts instead?

     - translation of $V = 100 \sqrt{E}$ one unit down
Chapter 10

10-1 Enrichment

Cubic Root Functions

A cubic root function contains the cubic root of a variable. The cubic root of a number \( x \) are the numbers \( y \) that satisfy the equation \( y \cdot y \cdot y = x \) (or, alternatively, \( y = \sqrt[3]{x} \)). Unlike square root functions, cubic root functions return real numbers when the radicand is negative.

Example 1: Graph \( y = \sqrt[3]{x} \).

Step 1: Make a table.

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-8</td>
<td>-2</td>
</tr>
<tr>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>

Step 2: Plot points and draw a smooth curve.

Exercises

Graph each function, and compare to the parent graph.

1. \( y = 2 \sqrt[3]{x} \)
2. \( y = \sqrt[3]{x} + 1 \)
3. \( y = \sqrt{x} + 1 \)

Chapter 10

10-2 Study Guide and Intervention

Simplifying Radical Expressions

Product Property of Square Roots: The Product Property of Square Roots and prime factorization can be used to simplify expressions involving irrational square roots. When you simplify radical expressions with variables, use absolute value to ensure nonnegative results.

Example 1: Simplify \( \sqrt{180} \).

\[ \sqrt{180} = \sqrt{2 \cdot 3 \cdot 3 \cdot 5} \]

Product Property of Square Roots

\[ = 2 \cdot 3 \cdot \sqrt{5} \]

Prime factorization of 180

\[ = 6\sqrt{5} \]

Simplify

Example 2: Simplify \( \sqrt{120a^2 \cdot b^5 \cdot c^3} \).

\[ \sqrt{120a^2 \cdot b^5 \cdot c^3} \]

\[ = \sqrt{2^2 \cdot 3 \cdot 5 \cdot a^2 \cdot b^5 \cdot c^3} \]

\[ = 2 \cdot 2 \cdot \sqrt{3 \cdot \sqrt{5} \cdot a^2 \cdot b^5 \cdot c^3} \]

\[ = 2a b^3 c \sqrt{30b^2} \]

Exercises

Simplify each expression.

1. \( \sqrt{28} \)
2. \( \sqrt{68} \)
3. \( \sqrt{60} \)
4. \( \sqrt{75} \)
5. \( \sqrt{182} \)
6. \( \sqrt{32} \cdot \sqrt{6} \)
7. \( \sqrt{25} \cdot \sqrt{8} \)
8. \( \sqrt{5} \cdot \sqrt{10} \)
9. \( \sqrt{3a^2} \)
10. \( \sqrt{9c^2} \)
11. \( \sqrt{300a^2} \)
12. \( \sqrt{125c^2} \)
13. \( \sqrt{40} \cdot \sqrt{36} \)
14. \( \sqrt{32} \cdot \sqrt{54} \)
15. \( \sqrt{20a^2b^4} \)
16. \( \sqrt{100a^2b^2} \)
17. \( \sqrt{24a^3b^4} \)
18. \( \sqrt{91x^2y^2} \)
19. \( \sqrt{150a^2b^2c^2} \)
20. \( \sqrt{72ab^2c^3} \)
21. \( \sqrt{45x^2y^2} \)
22. \( \sqrt{98xy^2z^2} \)

Chapter 10

10 Glencoe Algebra 1

Glencoe Algebra 1
10-2 **Study Guide and Intervention** (continued)

**Simplifying Radical Expressions**

**Quotient Property of Square Roots** A fraction containing radicals is in simplest form if no radicals are left in the denominator. The **Quotient Property of Square Roots** and rationalizing the denominator can be used to simplify radical expressions that involve division. When you rationalize the denominator, you multiply the numerator and denominator by a radical expression that gives a rational number in the denominator.

| Quotient Property of Square Roots | For any numbers $a$ and $b$, where $a \geq 0$ and $b > 0$, $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$. |

**Example** Simplify $\frac{\sqrt{56}}{45}$.

\[
\frac{\sqrt{56}}{45} = \frac{\sqrt{9 \cdot 11}}{3 \cdot \sqrt{15}} = \frac{3 \sqrt{11}}{3 \cdot \sqrt{15}} = \frac{\sqrt{11}}{\sqrt{15}} = \frac{\sqrt{11} \cdot \sqrt{15}}{15}
\]

**Exercises**

Simplify each expression.

1. $\frac{\sqrt{28}}{2}$
2. $\frac{\sqrt{9}}{3} = \frac{3}{3}$
3. $\frac{\sqrt{100}}{11} = \frac{10}{11}$
4. $\frac{\sqrt{5}}{5}$
5. $\frac{\sqrt{2}}{\sqrt{8}} = \frac{\sqrt{2}}{2\sqrt{2}}$
6. $\frac{\sqrt{12}}{\sqrt{2}} = \frac{\sqrt{6}}{\sqrt{2}}$
7. $\frac{\sqrt{4} \cdot \sqrt{2}}{\sqrt{4}} = \frac{\sqrt{50}}{2}$
8. $\frac{\sqrt{2}}{\sqrt{5}} = \frac{\sqrt{10}}{\sqrt{5}}$
9. $\frac{\sqrt{30}}{10\sqrt{5}}$
10. $\frac{\sqrt{5}}{\sqrt{3}}$
11. $\frac{\sqrt{100}}{\sqrt{44}} = \frac{10}{\sqrt{11}}$
12. $\frac{\sqrt{5ab}}{\sqrt{bc}}$
13. $\frac{\sqrt{2}}{\sqrt{3}}$
14. $\frac{\sqrt{28}}{\sqrt{4}} = \frac{\sqrt{7}}{\sqrt{2}}$
15. $\frac{\sqrt{45}}{\sqrt{2}}$
16. $\frac{\sqrt{3}}{\sqrt{2}}$
17. $\frac{\sqrt{5}}{\sqrt{3}}$
18. $\frac{\sqrt{12}}{\sqrt{5}}$
19. $\frac{\sqrt{2}}{\sqrt{3}}$
20. $\frac{\sqrt{2}}{\sqrt{3}}$
21. $\frac{\sqrt{2} - \sqrt{3}}{\sqrt{2} + \sqrt{3}}$
22. $\frac{\sqrt{2} - \sqrt{3}}{\sqrt{2} + \sqrt{3}}$
23. $\frac{\sqrt{2} - \sqrt{3}}{\sqrt{2} + \sqrt{3}}$
24. $\frac{\sqrt{2} - \sqrt{3}}{\sqrt{2} + \sqrt{3}}$
25. $\frac{\sqrt{2} - \sqrt{3}}{\sqrt{2} + \sqrt{3}}$
26. $\frac{\sqrt{2} - \sqrt{3}}{\sqrt{2} + \sqrt{3}}$
When a skydiver jumps from an airplane, the time \( t \) it takes to free fall a given distance can be estimated by the formula \( t = \sqrt{\frac{d}{2g}} \), where \( t \) is in seconds and \( d \) is in meters. If Julie jumps from an airplane, how long will it take her to free fall 750 meters? About 12.4 s

26. METEOROLOGY To estimate how long a thunderstorm will last, meteorologists can use the formula \( t = \sqrt{\frac{d}{216}} \) where \( t \) is the time in hours and \( d \) is the diameter of the storm in miles.

a. A thunderstorm is 8 miles in diameter. Estimate how long the storm will last.
   Give your answer in simplified form and as a decimal.
   \( 8 \frac{1}{2} h = 1.5 h \)

b. Will a thunderstorm twice this diameter last twice as long? Explain.
   No; it will last about 4.4 h, or nearly 3 times as long.

7. \( \sqrt{\frac{5}{7}} \cdot 3\sqrt{18} \)

8. \( \sqrt{27tu} 

9. \( \sqrt{56p^3} \)

10. \( \sqrt{108x^5y^2z^3} \)

11. \( \sqrt{96m^2n^2p^4} \)

12. \( \sqrt{\frac{9}{32}} \)

13. \( \sqrt{\frac{10}{8}} \)

14. \( \sqrt{\frac{15}{5}} \)

15. \( \sqrt{\frac{27}{4}} \)

16. \( \sqrt{\frac{11}{12}} \)

17. \( \sqrt{\frac{27}{4}} \)

18. \( \sqrt{\frac{18}{27}} \)

19. \( \sqrt{\frac{3}{2}} \)

20. \( \sqrt{\frac{3}{4}} \)

21. \( \sqrt{\frac{1}{2}} \)

22. \( \sqrt{\frac{3}{2}} \)

23. \( \sqrt{\frac{1}{2}} \)

24. \( \sqrt{\frac{1}{2}} \)

25. SKYDIVING When a skydiver jumps from an airplane, the time \( t \) it takes to free fall a given distance can be estimated by the formula \( t = \sqrt{\frac{d}{2g}} \), where \( t \) is in seconds and \( s \) is in meters. If Julie jumps from an airplane, how long will it take her to free fall 750 meters?

2. \( \sqrt{\frac{5}{7} \cdot 7\sqrt{2}} \)

3. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

4. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

5. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

6. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

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14. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

15. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

16. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

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19. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

20. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

21. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

22. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

23. \( \sqrt{\frac{5}{7} \cdot 3\sqrt{18}} \)

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b. Will a thunderstorm twice this diameter last twice as long? Explain.
   No; it will last about 4.4 h, or nearly 3 times as long.
10-2 Enrichment

Squares and Square Roots From a Graph

The graph of \( y = x^2 \) can be used to find the squares and square roots of numbers.

Example

The arrows show that 3² = 9. To find the square root of 9, first locate 9 on the x-axis. Then find its corresponding value on the y-axis. Following the arrows on the graph, you can see that \( \sqrt{9} = 3 \).

Example 2

A small part of the graph at \( y = x^2 \) is shown below. A 1:10 ratio for unit length on the x-axis is used.

Exercises

Use the graph above to find each of the following to the nearest whole number.

1. 1.15° 2
2. 2.7° 7
3. 0.9° 1
4. 3.6° 13
5. 4.2° 18
6. 3.9° 15

Use the graph above to find each of the following to the nearest tenth.

7. \( \sqrt{15} \) 3.9
8. \( \sqrt{8} \) 2.8
9. \( \sqrt{3} \) 1.7
10. \( \sqrt{2} \) 2.2
11. \( \sqrt{14} \) 3.7
12. \( \sqrt{17} \) 4.1

10-3 Study Guide and Intervention

Operations with Radical Expressions

Add or Subtract Radical Expressions

When adding or subtracting radical expressions, use the Associative and Distributive Properties to simplify the expressions. If radical expressions are not in simplest form, simplify them.

Example 1

Simplify \( 10\sqrt{6} - 5\sqrt{3} + 6\sqrt{3} - 4\sqrt{6} \).

\[
10\sqrt{6} - 5\sqrt{3} + 6\sqrt{3} - 4\sqrt{6} = (10 - 4)\sqrt{6} + (-5 + 6)\sqrt{3} = 6\sqrt{6} + \sqrt{3}
\]

Example 2

Simplify \( 3\sqrt{12} + 5\sqrt{75} \).

\[
3\sqrt{12} + 5\sqrt{75} = 3\sqrt{2^2 \cdot 3} + 5\sqrt{3^2 \cdot 5} = 3 \cdot 2\sqrt{3} + 5 \cdot 5\sqrt{3} = 6\sqrt{3} + 25\sqrt{3} = 31\sqrt{3}
\]

Exercises

Simplify each expression.

1. \( 2\sqrt{5} + 4\sqrt{5} \) \( 6\sqrt{5} \)
2. \( \sqrt{6} - 4\sqrt{6} \) \( -3\sqrt{6} \)
3. \( \sqrt{3} - \sqrt{2} \) \( \sqrt{2} \)
4. \( 3\sqrt{15} + 2\sqrt{5} \) \( 15\sqrt{3} + 2\sqrt{5} \)
5. \( \sqrt{20} + 2\sqrt{5} - 3\sqrt{5} \) \( \sqrt{5} \)
6. \( 2\sqrt{3} + \sqrt{6} - 5\sqrt{3} \) \( -3\sqrt{3} + \sqrt{6} \)
7. \( \sqrt{12} + 2\sqrt{3} - 5\sqrt{3} \) \( -\sqrt{3} \)
8. \( 3\sqrt{6} + 3\sqrt{2} - \sqrt{50} + \sqrt{24} \) \( 5\sqrt{6} - 2\sqrt{2} \)
9. \( \sqrt{50} - \sqrt{20} + 5\sqrt{2} \) \( 6\sqrt{2}a \)
10. \( \sqrt{54} + \sqrt{24} \) \( 5\sqrt{6} \)
11. \( \sqrt{3} + \sqrt{6} \) \( \frac{4\sqrt{3}}{3} \)
12. \( \sqrt{12} + \sqrt{3} \) \( \frac{7\sqrt{3}}{3} \)
13. \( \sqrt{54} - \sqrt{18} \) \( \frac{17\sqrt{6}}{6} \)
14. \( \sqrt{50} - \sqrt{20} + \sqrt{80} \) \( 8\sqrt{5} \)
15. \( \sqrt{50} + \sqrt{18} - \sqrt{75} + 2\sqrt{2} \) \( 8\sqrt{2} - 2\sqrt{3} \)
16. \( 2\sqrt{3} - 4\sqrt{5} + 2\sqrt{15} \) \( \frac{8\sqrt{5}}{3} - 12\sqrt{5} \)
17. \( \sqrt{125} - 2\sqrt{5} + \sqrt{\frac{23\sqrt{5}}{5}} + \sqrt{\frac{5}{3}} \)
18. \( \sqrt{\frac{2}{3}} + 3\sqrt{3} - 4\sqrt{12} \) \( \sqrt{6} + 7\sqrt{3} \)
10-3 Skills Practice  

**Operations with Radical Expressions**

Simplify each expression.

1. \( \sqrt{7} - 2\sqrt{7} \)  
2. \( 3\sqrt{13} + 7\sqrt{13} \)  
3. \( 6\sqrt{5} - 2\sqrt{5} + 8\sqrt{5} \)  
4. \( 4\sqrt{15} + 8\sqrt{15} - 12\sqrt{15} \)  
5. \( 12\sqrt{7} - 9\sqrt{7} \)  
6. \( 6\sqrt{6a} - 11\sqrt{6a} + 4\sqrt{6a} \)  
7. \( \sqrt{44} - \sqrt{11} \)  
8. \( \sqrt{28} + \sqrt{63} \)  
9. \( 4\sqrt{3} + 2\sqrt{12} \)  
10. \( 8\sqrt{5} - 4\sqrt{6} \)  
11. \( \sqrt{27} + \sqrt{48} + \sqrt{12} \)  
12. \( \sqrt{72} + \sqrt{50} - \sqrt{8} \)  
13. \( \sqrt{130} - 5\sqrt{5} + \sqrt{20} \)  
14. \( 2\sqrt{24} + 4\sqrt{54} + 5\sqrt{96} \)  
15. \( 5\sqrt{8} + 2\sqrt{20} - \sqrt{8} \)  
16. \( 2\sqrt{15} + \sqrt{42} - 5\sqrt{13} + \sqrt{2} \)  
17. \( \sqrt{2}(\sqrt{6} + \sqrt{5}) \)  
18. \( \sqrt{3}(\sqrt{10} - \sqrt{3}) \)  
19. \( \sqrt{5}(3\sqrt{2} - 2\sqrt{3}) \)  
20. \( 3\sqrt{3}(2\sqrt{6} + 4\sqrt{10}) \)  
21. \( (4 + \sqrt{3})(4 - \sqrt{3}) \)  
22. \( (2 - \sqrt{6})^2 \)  
23. \( (\sqrt{6} + \sqrt{3})(\sqrt{5} + \sqrt{3}) \)  
24. \( (\sqrt{6} + 4\sqrt{5})(4\sqrt{3} - 10) \)
1. \(8\sqrt{30} - 4\sqrt{30}\)  
2. \(2\sqrt{5} - 7\sqrt{5} - 5\sqrt{5}\)  
3. \(7\sqrt{13x} - 14\sqrt{13x} + 2\sqrt{13x}\)  
4. \(2\sqrt{45} + 4\sqrt{20}\)  
5. \(\sqrt{40} - \sqrt{10} + \sqrt{90}\)  
6. \(2\sqrt{32} + 3\sqrt{50} - 3\sqrt{18}\)  
7. \(\sqrt{27} + \sqrt{18} + \sqrt{100}\)  
8. \(5\sqrt{8} + 3\sqrt{20} - \sqrt{32}\)  
9. \(\sqrt{14} - \frac{7}{5}\)  
10. \(\sqrt{50} + \sqrt{32} - \sqrt{1\cdot 2}\)  
11. \(5\sqrt{19} + 4\sqrt{28} - 8\sqrt{19} + \sqrt{63}\)  
12. \(3\sqrt{10} + \sqrt{75} - 2\sqrt{40} - 4\sqrt{12}\)  
13. \(-3\sqrt{9} + 11\sqrt{7}\)  
14. \(\sqrt{50} - 3\sqrt{3}\)  
15. \(2\sqrt{3}(\sqrt{12} + 5\sqrt{6})\)  
16. \((5 - \sqrt{15})^2\)  
17. \((\sqrt{10} + \sqrt{5})(\sqrt{30} - \sqrt{18})\)  
18. \((\sqrt{8} + \sqrt{12})(\sqrt{48} + \sqrt{18})\)  
19. \((\sqrt{2} + 2\sqrt{5})(3\sqrt{6} - \sqrt{5})\)  
20. \((4\sqrt{5} - 2\sqrt{5})(\sqrt{10} + 5\sqrt{6})\)  
21. \(30\sqrt{3} - 5\sqrt{10}\)  
22. \(2\sqrt{30} + 30\sqrt{2}\)

21. SOUND The speed of sound \(V\) in meters per second near Earth’s surface is given by \(V = 20\sqrt{t + 273}\), where \(t\) is the surface temperature in degrees Celsius.

a. What is the speed of sound near Earth’s surface at 15°C and at 2°C in simplest form?  
   - 240\(\sqrt{2}\) m/s, 100\(\sqrt{11}\) m/s

b. How much faster is the speed of sound at 15°C than at 2°C?  
   - \(240\sqrt{2} - 100\sqrt{11}\) ≈ 775.3 m/s

22. GEOMETRY A rectangle is 5\(\sqrt{7} + 2\sqrt{3}\) meters long and 6\(\sqrt{7} - 3\sqrt{3}\) meters wide.

a. Find the perimeter of the rectangle in simplest form.  
   - 22\(\sqrt{7} - 2\sqrt{3}\) m

b. Find the area of the rectangle in simplest form.  
   - 190 - 3\(\sqrt{21}\) m²

Chapter 10

Practice Operations with Radical Expressions

Simplify each expression.

1. \(8\sqrt{30} - 4\sqrt{30}\)
2. \(2\sqrt{5} - 7\sqrt{5} - 5\sqrt{5}\)
3. \(7\sqrt{13x} - 14\sqrt{13x} + 2\sqrt{13x}\)
4. \(2\sqrt{45} + 4\sqrt{20}\)
5. \(\sqrt{40} - \sqrt{10} + \sqrt{90}\)
6. \(2\sqrt{32} + 3\sqrt{50} - 3\sqrt{18}\)
7. \(\sqrt{27} + \sqrt{18} + \sqrt{100}\)
8. \(5\sqrt{8} + 3\sqrt{20} - \sqrt{32}\)
9. \(\sqrt{14} - \frac{7}{5}\)
10. \(\sqrt{50} + \sqrt{32} - \sqrt{1\cdot 2}\)
11. \(5\sqrt{19} + 4\sqrt{28} - 8\sqrt{19} + \sqrt{63}\)
12. \(3\sqrt{10} + \sqrt{75} - 2\sqrt{40} - 4\sqrt{12}\)
13. \(-3\sqrt{9} + 11\sqrt{7}\)
14. \(\sqrt{50} - 3\sqrt{3}\)
15. \(2\sqrt{3}(\sqrt{12} + 5\sqrt{6})\)
16. \((5 - \sqrt{15})^2\)
17. \((\sqrt{10} + \sqrt{5})(\sqrt{30} - \sqrt{18})\)
18. \((\sqrt{8} + \sqrt{12})(\sqrt{48} + \sqrt{18})\)
19. \((\sqrt{2} + 2\sqrt{5})(3\sqrt{6} - \sqrt{5})\)
20. \((4\sqrt{5} - 2\sqrt{5})(\sqrt{10} + 5\sqrt{6})\)
21. \(30\sqrt{3} - 5\sqrt{10}\)
22. \(2\sqrt{30} + 30\sqrt{2}\)

23. SOUND The speed of sound \(V\) in meters per second near Earth’s surface is given by \(V = 20\sqrt{t + 273}\), where \(t\) is the surface temperature in degrees Celsius.

a. What is the speed of sound near Earth’s surface at 15°C and at 2°C in simplest form?  
   - 240\(\sqrt{2}\) m/s, 100\(\sqrt{11}\) m/s

b. How much faster is the speed of sound at 15°C than at 2°C?  
   - \(240\sqrt{2} - 100\sqrt{11}\) ≈ 775.3 m/s

24. GEOMETRY A rectangle is 5\(\sqrt{7} + 2\sqrt{3}\) meters long and 6\(\sqrt{7} - 3\sqrt{3}\) meters wide.

a. Find the perimeter of the rectangle in simplest form.  
   - 22\(\sqrt{7} - 2\sqrt{3}\) m

b. Find the area of the rectangle in simplest form.  
   - 190 - 3\(\sqrt{21}\) m²

Chapter 10 Word Problem Practice Operations with Radical Expressions

1. ARCHITECTURE The Pentagon is the building that houses the U.S. Department of Defense. Find the approximate perimeter of the building, which is a regular pentagon. Leave your answer as a radical expression.

The Pentagon is the following formula to find how many square kilometers, what is the radius of Earth to the nearest ten kilometers?

6370 km

3. GEOMETRY The area of a trapezoid is found by multiplying its height by the average length of its bases. Find the area of deck attached to Mr. Wilson’s house. Give your answer as a simplified radical expression.

63\(\sqrt{15}\) ft²

4. RECREATION Carmen surveyed a ski slope using a digital device connected to a computer. The computer model assigned coordinates to the top and bottom points of the hill as shown in the diagram. Write a simplified radical expression that represents the slope of the hill.

\[ A(2\sqrt{15}, 5\sqrt{2}) \]

5. FREE FALL Suppose a ball is dropped from a building window 800 feet in the air. Another ball is dropped from a lower window 288 feet high. Both balls are released at the same time. Assume air resistance is not a factor and use the following formula to find how many seconds \(t\) it will take for each ball to fall to the ground:

\[ t = \frac{1}{4\sqrt{g}} \]

a. How much time will pass between when the first ball hits the ground and when the second ball hits the ground? Give your answer as a simplified radical expression.

\(2\sqrt{2}\ s\)

b. Which ball lands first? The ball dropped from 288 feet lands first.

c. Find a decimal approximation of the answer for part a. Round your answer to the nearest tenth. About \(2.8\ s\)
10-3 Enrichment

The Wheel of Theodorus

The Greek mathematicians were intrigued by problems of representing different numbers and expressions using geometric constructions.

Theodorus, a Greek philosopher who lived about 425 B.C., is said to have discovered a way to construct the sequence \(1, \sqrt{2}, \sqrt{3}, \sqrt{4}, \ldots\). The beginning of his construction is shown. You start with an isosceles right triangle with sides 1 unit long.

Use the figure above. Write each length as a radical expression in simplest form.

1. Line segment \(AO \sqrt{1}\)
2. Line segment \(BO \sqrt{2}\)
3. Line segment \(CO \sqrt{3}\)
4. Line segment \(DO \sqrt{4}\)

5. Describe how each new triangle is added to the figure. Draw a new side of length 1 at right angles to the last hypotenuse. Then draw the new hypotenuse.

6. The length of the hypotenuse of the first triangle is \(\sqrt{2}\). For the second triangle, the length is \(\sqrt{3}\). Write an expression for the length of the hypotenuse of the \(n\)th triangle.

\(\sqrt{n + 1}\)

7. Show that the method of construction will always produce the next number in the sequence. (Hint: Find an expression for the hypotenuse of the \((n+1)\)th triangle.)

\(\sqrt{((n+1)/2)^2 + 1^2} = \sqrt{n + 1}\)

8. In the space below, construct a Wheel of Theodorus. Start with a line segment 1 centimeter long. When does the Wheel start to overlap?

after length \(\sqrt{18}\)

10-4 Study Guide and Intervention

Radical Equations

Equations containing radicals with variables in the radicand are called radical equations. These can be solved by first using the following steps.

Step 1. Isolate the radical on one side of the equation.
Step 2. Square each side of the equation to eliminate the radical.

Example 1
Solve \(16 = \frac{\sqrt{x}}{2}\) for \(x\).

1. \(16 = \frac{\sqrt{x}}{2}\) Original equation
2. \(2(16) = 2 \cdot \frac{\sqrt{x}}{2}\) Multiply each side by 2.
3. \(32 = \sqrt{x}\) Simplify.
4. \((32)^2 = (\sqrt{x})^2\) Square each side.
5. \(1024 = x\) Simplify.

The solution is 1024, which checks in the original equation.

Example 2
Solve \(\sqrt{4x - 7} + 2 = 7\).

1. \(\sqrt{4x - 7} + 2 = 7\) Original equation
2. \(\sqrt{4x - 7} = 5\) Subtract 2 from each side.
3. \((\sqrt{4x - 7})^2 = 5^2\) Square each side.
4. \(4x - 7 = 25\) Simplify.
5. \(4x = 32\) Add 7 to each side.
6. \(x = 8\) Divide each side by 4.

The solution is 8, which checks in the original equation.

Exercises

Solve each equation. Check your solution.

1. \(\sqrt{x} = 8\) 
2. \(\sqrt{x} + 6 = 32\) 
3. \(2\sqrt{x} = 8\)

4. \(7 = \sqrt{26 - n}\) 
5. \(\sqrt{n} - 6 = 36\) 
6. \(\sqrt{3n} = 3\) ± \(\sqrt{3}\)

7. \(2\sqrt{3} = \sqrt{5}\) 
8. \(2\sqrt{3} - 2 = 7\) 
9. \(\sqrt{x} - 4 = 6\)

10. \(\sqrt{2m + 3} = 5\) 
11. \(\sqrt{36 - 2} + 19 = 24\) 
12. \(\sqrt{4x} = 1\) ± \(\frac{5}{2}\)

13. \(\sqrt{3}r + 2 = 2\sqrt{5}\) 
14. \(\sqrt{x} = \frac{1}{2}\) 
15. \(\frac{1}{2}\) 

16. \(\sqrt{6x^2 + 5x} = 2\) 
17. \(\sqrt{6} + 6 = 8\) 
18. \(2\sqrt{5} + 3 = 11\)

Chapter 10
10-4 Study Guide and Intervention

Radical Equations

Extraneous Solutions To solve a radical equation with a variable on both sides, you need to square each side of the equation. Squaring each side of an equation sometimes produces extraneous solutions, or solutions that are not solutions of the original equation. Therefore, it is very important that you check each solution.

Example 1 Solve \( \sqrt{x + 3} = x - 3 \).

\[
\begin{align*}
\sqrt{x + 3} &= x - 3 & \text{Original equation} \\
(x + 3)^2 &= (x - 3)^2 & \text{Square each side.} \\
x + 3 &= x^2 - 6x + 9 & \text{Simplify.} \\
0 &= x^2 - 7x + 6 & \text{Subtract } x \text{ and } 3 \text{ from each side.} \\
0 &= (x - 1)(x - 6) & \text{Factor} \\
x - 1 = 0 & \text{ or } x - 6 = 0 & \text{Zero Product Property} \\
x = 1 & \text{ or } x = 6 & \text{Solve.} \\
\end{align*}
\]

CHECK \( \sqrt{1 + 3} = 1 - 3 \)

\( \sqrt{4} = -2 \)

\( 2 \neq -2 \)

\( 3 = 3 \checkmark \)

Since \( x = 1 \) does not satisfy the original equation, \( x = 6 \) is the only solution.

Exercises

Solve each equation. Check your solution.

1. \( \sqrt{x} = a \quad 0, 1 \)
2. \( \sqrt{a + 6} = a \quad 3 \)
3. \( 2\sqrt{x} = x \quad 0, 4 \)
4. \( n = \sqrt{2 - n} \quad 1 \)
5. \( \sqrt{-a} = a \quad 0 \)
6. \( \sqrt{10 - 6x} + 3 = k \quad \emptyset \)
7. \( \sqrt{y - 1} = y - 1 \quad 1, 2 \)
8. \( \sqrt{3a - 2} = a \quad 1, 2 \)
9. \( \sqrt{x + 2} = x \quad 2 \)
10. \( \sqrt{2b + 5} = b - 5 \quad 10 \)
11. \( \sqrt{b + 6} = b + 2 \quad 1 \)
12. \( \sqrt{4x - 4} = x \quad 2 \)
13. \( r + \sqrt{2 - r} = 2 \quad 1, 2 \)
14. \( \sqrt{x^2 + 10x} = x + 4 \quad 8 \)
15. \( -\sqrt{\frac{x}{8}} = 15 \quad \emptyset \)
16. \( \sqrt{ax^2 - 4x} = x + 2 \quad 8 \)
17. \( \sqrt{2x^2 - 64} = y \quad -4, 3 \)
18. \( \sqrt{3x^2 + 12x + 1} = x + 5 \)

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Answers (Lesson 10-4)
1. \( \sqrt{-5} = 8 \) \(-64 \)
2. \( 2\sqrt{3} = \sqrt{48} \)
3. \( 2\sqrt{4r + 3} = 11 \) \(4 \)
4. \( 4.6 - \sqrt{2y} = -2 \) \(32 \)
5. \( \sqrt{b} + 2 - 3 = 7 \) \(98 \)
6. \( 6\sqrt{m} - 5 = 4\sqrt{3} \) \(53 \)
7. \( \sqrt{8x + 12} = 8\sqrt{6} \) \(62 \)
8. \( 8\sqrt{3y - 11} + 2 = 9 \) \(20 \)
9. \( \sqrt{2x + 15} + 5 = 18 \) \(77 \)
10. \( \sqrt{3a} + 4 = 2 \) \(60 \)
11. \( \sqrt{\frac{3x}{3} - 3} = 6 \) \(\frac{1}{4} \)
12. \( 12.6 + \sqrt{\frac{5x}{6}} = -2 \) \(\emptyset \)
13. \( y = \sqrt{y + 6} \) \(3 \)
14. \( 14\sqrt{15 - 2x} = x \) \(3 \)
15. \( \sqrt{w + 4} = w - 4 \) \(-3 \)
16. \( 16\sqrt{17 - k} = k - 5 \) \(8 \)
17. \( \sqrt{2m - 16} = m - 2 \) \(4 \) \(5 \)
18. \( 18\sqrt{24 + 8q} = q + 3 \) \(-3 \) \(5 \)
19. \( t\sqrt{17 - t} - 3 = 0 \) \(2 \)
20. \( 20.4 - \sqrt{3m + 28} = m \) \(-1 \)
21. \( \sqrt{10p + 61} - 7 = p \) \(-6 \) \(2 \)
22. \( 22\sqrt{2x^2 - 9} = x \) \(3 \)
23. ELECTRICITY. The voltage \( V \) in a circuit is given by \( V = \sqrt{PR} \), where \( P \) is the power in watts and \( R \) is the resistance in ohms.
   a. If the voltage in a circuit is 120 volts and the circuit produces 1500 watts of power, what is the resistance in the circuit? \( 9.6 \) ohms
   b. Suppose an electrician designs a circuit with 110 volts and a resistance of 10 ohms. How much power will the circuit produce? \( 660 \) watts
24. FREE FALL. Assuming no air resistance, the time \( t \) in seconds that it takes an object to fall \( h \) feet can be determined by the equation \( t = \sqrt{\frac{h}{9.8}} \).
   a. If a skydiver jumps from an airplane and free falls for 10 seconds before opening the parachute, how many feet does the skydiver fall? \( 1800 \) ft
   b. Suppose a second skydiver jumps and free falls for 6 seconds. How many feet does the second skydiver fall? \( 576 \) ft

1. SUBMARINES. The distance in miles that the lookout of a submarine can see is approximately \( d = 1.22\sqrt{h} \), where \( h \) is the height in feet above the surface of the water. How far would a submarine periscope have to be above the water to locate a ship 6 miles away? Round your answer to the nearest tenth. \( 24.2 \) ft
2. PETS. Find the value of \( x \) if the perimeter of a triangular dog pen is 25 meters. \( x = 8 \)
3. LOGGING. Doyle's log rule estimates the amount of usable lumber (in board feet) that can be milled from a shipment of logs. It is represented by the equation \( B = d^{\frac{1}{4}} \), where \( d \) is the log diameter (in inches) and \( L \) is the log length (in feet). Suppose the truck carries 20 logs, each 25 feet long, and that the shipment yields a total of 6000 board feet of lumber. Estimate the diameter of the logs to the nearest inch. Assume that all the logs have uniform length and diameter. \( 18 \) in.
4. FIREFIGHTING. Fire fighters calculate the flow rate of water out of a particular hydrant by using the following formula.
   \( F = 26.9\sqrt{p} \)
   \( F \) is the flow rate (in gallons per minute), \( p \) is the nozzle pressure (in pounds per square inch), and \( d \) is the diameter of the hose (in inches). In order to effectively fight a fire, the combined flow rate of two hoses needs to be about 2430 gallons per minute. The diameter of each of the hoses is 3 inches, but the nozzle pressure of one hose is 4 times that of the second hose. What are the nozzle pressures for each hose? Round your answers to the nearest tenth.
   11.2 psi and 44.8 psi
5. GEOMETRY. The lateral surface area \( s \) of a right circular cone, not including the base, is represented by the equation \( s = \pi\sqrt{r^2 + h^2} \), where \( r \) is the radius of the circular base and \( h \) is the height of the cone.
   a. If the lateral surface area of a funnel is 127.54 square centimeters and its radius is 3.5 centimeters, find its height to the nearest tenth of a centimeter. \( 11.1 \) cm
   b. What is the area of the opening (i.e., the base) of the funnel? \( 38.5 \) cm²
More Than One Square Root
You have learned that to remove the square root in an equation, you first need to isolate the square root, then square both sides of the equation, and finally, solve the resulting equation. However, there are equations that contain more than one square root and simply squaring once is not enough to remove all of the radicals.

Example
Solve \( \sqrt{x + 7} = \sqrt{x} + 1 \).

\[
\begin{align*}
\sqrt{x + 7} &= \sqrt{x} + 1 \\
(\sqrt{x + 7})^2 &= (\sqrt{x} + 1)^2 \\
x + 7 &= x + 2\sqrt{x} + 1 \\
6 &= 2\sqrt{x} \\
3 &= \sqrt{x} \\
x &= 9
\end{align*}
\]

Check: Substitute into the original equation to make sure your solution is valid.
\[
\sqrt{9 + 7} = \sqrt{9} + 1 \\
\sqrt{16} = 3 + 1 \\
4 = 4 \checkmark
\]

Exercises
Solve each equation.

1. \( \sqrt{x + 13} - 2 = \sqrt{x} + 1 \)  
2. \( \sqrt{x + 11} = \sqrt{x + 3} + 2 \)  
3. \( \sqrt{x + 3} - 3 = \sqrt{x} - 6 \)  
4. \( \sqrt{x + 21} = \sqrt{x} + 3 \)  
5. \( \sqrt{x + 9} + 3 = \sqrt{x} + 20 + 2 \)  
6. \( \sqrt{x - 6} + 6 = \sqrt{x} + 1 + 5 \)

10-4 Graphing Calculator Activity

Radical Inequalities
The graphs of radical equations can be used to determine the solutions of radical inequalities through the CALC menu.

Example
Solve each inequality.

a. \( \sqrt{x} + 4 \leq 3 \)
Enter \( \sqrt{x} + 4 \) in \( Y_1 \) and \( 3 \) in \( Y_2 \) and graph. Examine the graphs. Use TRACE to find the endpoint of the graph of the radical equation. Use CALC to determine the intersection of the graphs. This interval \(-4 \leq x \leq 5\), where the graph of \( y = \sqrt{x} + 4 \) is below the graph of \( y = 3 \), represents the solution to the inequality. Thus, the solution is \(-4 \leq x \leq 5\).

b. \( \sqrt{2x - 5} > x - 4 \)
Graph each side of the inequality. Find the intersection and trace to the endpoint of the radical graph.
The graph of \( y = \sqrt{2x - 5} \) is above the graph of \( y = x - 4 \) from 2.5 up to 7. Thus, the solution is \( 2.5 < x < 7 \).

Exercises
Solve each inequality.

1. \( 6 - \sqrt{2x + 1} < 3 \)  
2. \( \sqrt{4x - 5} \leq 7 \)  
3. \( \sqrt{3x} - 4 \geq 4 \)
4. \( x > 4 \)  
5. \( \frac{5}{4} \leq x \leq \frac{27}{2} \)  
6. \( \sqrt{6 - 3x} < x + 16 \)  
no solution
7. \( x \geq 2 \)  
8. \( -10 < x < 2 \)
The Pythagorean Theorem

The side opposite the right angle in a right triangle is called the hypotenuse. This side is always the longest side of a right triangle. The other two sides are called the legs of the triangle. To find the length of any side of a right triangle, given the lengths of the other two sides, you can use the Pythagorean Theorem.

If \( a \) and \( b \) are the measures of the shorter sides of a triangle, \( c \) is the measure of the longest side, and \( c^2 = a^2 + b^2 \), then the triangle is a right triangle.

Example

Find the length of the missing side.

\[
c^2 = a^2 + b^2\]

- \( a = 5 \) and \( b = 12 \)
- \( c = \sqrt{169} \) Simplify. \( c = 13 \)

The length of the hypotenuse is 13.

Exercises

Find the length of each missing side. If necessary, round to the nearest hundredth.

1. \( a = 30 \) and \( b = 40 \)
   \( c = \sqrt{50} \) \( c = 5 \sqrt{2} \)

2. \( a = 100 \) and \( b = 110 \)
   \( c = \sqrt{3100} \) \( c \approx 55.7 \\

3. \( a = 25 \) and \( b = 21 \)
   \( c = \sqrt{850} \) \( c \approx 29.2 \\

4. \( a = 14 \) and \( b = 8 \)
   \( c = \sqrt{240} \) \( c \approx 15.5 \\

5. \( a = 15 \) and \( b = \sqrt{75} \)
   \( c = \sqrt{225} \) \( c = 15 \\

6. \( a = 5 \) and \( b = \sqrt{11} \)
   \( c = \sqrt{31} \) \( c \approx 5.6 \\

Right Triangles

If \( a \) and \( b \) are the measures of the shorter sides of a triangle, \( c \) is the measure of the longest side, and \( c^2 = a^2 + b^2 \), then the triangle is a right triangle.

Example

Determine whether the following side measures form a Pythagorean triple.

- \( a = 10, b = 12, c = 14 \)

Since the measure of the longest side is 14, let \( c = 14 \), and \( a = 10, b = 12 \).

\[
a^2 + b^2 = 10^2 + 12^2 = 100 + 144 = 244\]

\[
c^2 = 14^2 = 196\]

Since \( c^2 \neq a^2 + b^2 \), the triangle is not a right triangle.

Exercises

Determine whether each set of measures can be sides of a right triangle. Then determine whether they form a Pythagorean triple.

- \( a = 14, b = 48, c = 50 \)

\( a^2 + b^2 = 14^2 + 48^2 = 196 + 2304 = 2500 \)

\( c^2 = 50^2 = 2500 \)

\( a^2 + b^2 = c^2 \)

Yes; yes

- \( a = 2, b = 2, c = \sqrt{8} \)

\( a^2 + b^2 = 2^2 + 2^2 = 4 + 4 = 8 \)

\( c^2 = (\sqrt{8})^2 = 8 \)

\( a^2 + b^2 = c^2 \)

Yes; yes

- \( a = 1, b = 2, c = \sqrt{5} \)

\( a^2 + b^2 = 1^2 + 2^2 = 1 + 4 = 5 \)

\( c^2 = (\sqrt{5})^2 = 5 \)

\( a^2 + b^2 = c^2 \)

Yes; yes

- \( a = 12, b = 30, c = 35 \)

\( a^2 + b^2 = 12^2 + 30^2 = 144 + 900 = 1044 \)

\( c^2 = 35^2 = 1225 \)

\( a^2 + b^2 \neq c^2 \)

No; no

- \( a = 15, b = 30, c = 35 \)

\( a^2 + b^2 = 15^2 + 30^2 = 225 + 900 = 1125 \)

\( c^2 = 35^2 = 1225 \)

\( a^2 + b^2 \neq c^2 \)

No; no

Answers (Lesson 10-5)
Skills Practice

The Pythagorean Theorem

Find the length of each missing side. If necessary, round to the nearest hundredth.

1. \[a = 21, \quad c = 34, \quad b = \sqrt{990} \approx 31.49\]

2. \[b = 36, \quad a = 15, \quad c = \sqrt{1170} \approx 33.90\]

3. \[c = 16, \quad a = 36, \quad b = \sqrt{1456} \approx 38.13\]

4. \[b = 24, \quad a = 12, \quad c = \sqrt{720} \approx 26.83\]

5. \[a = 20, \quad b = \sqrt{41}, \quad c = \sqrt{161} \approx 12.73\]

6. \[a = 12, \quad b = \sqrt{15}, \quad c = \sqrt{225} \approx 15.00\]

Determine whether each set of measures can be sides of a right triangle. Then determine whether they form a Pythagorean triple.

7. \[7, 24, 25 \quad \text{yes}; \text{yes}\]

8. \[15, 30, 34 \quad \text{no}; \text{no}\]

9. \[16, 28, 32 \quad \text{no}; \text{no}\]

10. \[18, 24, 30 \quad \text{yes}; \text{yes}\]

11. \[15, 36, 39 \quad \text{yes}; \text{yes}\]

12. \[5, 7, \sqrt{74} \quad \text{yes}; \text{no}\]

13. \[4, 5, 6 \quad \text{no}; \text{no}\]

14. \[10, 11, \sqrt{221} \quad \text{yes}; \text{no}\]

Practice

The Pythagorean Theorem

Find the length of each missing side. If necessary, round to the nearest hundredth.

1. \[a = 20, \quad b = 15, \quad c = \sqrt{625} = 25\]

2. \[a = 36, \quad b = 19, \quad c = \sqrt{1441} \approx 38.01\]

3. \[a = 12, \quad b = 5, \quad c = \sqrt{169} = 13\]

Determine whether each set of measures can be sides of a right triangle. Then determine whether they form a Pythagorean triple.

4. \[11, 18, 21 \quad \text{no}; \text{no}\]

5. \[52, 72, 75 \quad \text{yes}; \text{yes}\]

6. \[7, 8, 11 \quad \text{yes}; \text{no}\]

7. \[9, 10, \sqrt{161} \approx 12.69\]

8. \[8, 9, 2\sqrt{10}, 11 \quad \text{yes}; \text{no}\]

9. \[9, \sqrt{7}, \sqrt{2}, \sqrt{2} \approx 11.31\]

10. STORAGE The shed in Stephan’s back yard has a door that measures 6 feet high and 3 feet wide. Stephan would like to store a square theater prop that is 7 feet on a side. Will it fit through the door diagonally? Explain. No; the greatest length that will fit through the door is \(\sqrt{45} \approx 6.71\) ft.

11. SCREEN SIZES The size of a television is measured by the length of the screen’s diagonal.

a. If a television screen measures 24 inches high and 18 inches wide, what size television is it? 30-in. television

b. Darla told Tri that she has a 35-inch television. The height of the screen is 21 inches. What is its width? 28 in.

c. Tri told Darla that he has a 5-inch handheld television and that the screen measures 2 inches by 3 inches. Is this a reasonable measure for the screen size? Explain. No; if the screen measures 2 in. by 3 in., then its diagonal is only about 3.61 in.
**Word Problem Practice**

**Pythagorean Theorem**

1. **BASEBALL** A baseball diamond is a square. Each base path is 90 feet long. After a pitch, the catcher quickly throws the ball from home plate to a teammate standing by second base. Find the distance the ball travels. Round your answer to the nearest tenth.

   127.3 ft

2. **TRIANGLES** Each student in Mrs. Kelly’s geometry class constructed a unique right triangle from drinking straws. Mrs. Kelly made a chart with the dimensions of each triangle. However, Mrs. Kelly made a mistake when recording their results. Which result was recorded incorrectly?

3. **MAPS** Find the distance between Macon and Berryville. Round your answer to the nearest tenth.

   78.2 mi

4. **TELEVISION** Televisions are identified by the diagonal measurement of the viewing screen. For example, a 27-inch television has a diagonal screen measurement of 27 inches.

   Complete the chart to find the screen height of each television given its size and screen width. Round your answers to the nearest whole number.

<table>
<thead>
<tr>
<th>TV size</th>
<th>width (in)</th>
<th>height (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-inch</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>25-inch</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>32-inch</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>50-inch</td>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>

   Source: Best Buy

5. **MANUFACTURING** Karl works for a company that manufactures car parts. His job is to drill a hole in spherical steel balls. The balls and the holes have the dimensions shown on the diagram.

   - a. How deep is the hole? 12 cm
   - b. What would be the radius of a ball with a similar hole 7 centimeters wide and 24 centimeters deep? 12.5 cm

**Enrichment**

**Pythagorean Triples**

Recall the Pythagorean Theorem:

\[ a^2 + b^2 = c^2 \]

Note that \( c \) is the length of the hypotenuse.

The integers 3, 4, and 5 satisfy the Pythagorean Theorem and can be the sides of a right triangle.

Furthermore, for any positive integer \( n \), the numbers \( 3n \), \( 4n \), and \( 5n \) satisfy the Pythagorean Theorem. Here is an easy way to find other Pythagorean triples.

If three numbers satisfy the Pythagorean Theorem, they are called a Pythagorean triple.

The numbers \( a, b, \) and \( c \) are a Pythagorean triple if \( a = m^2 - n^2, b = 2mn, \) and \( c = m^2 + n^2 \), where \( m \) and \( n \) are relatively prime positive integers and \( m > n \).

**Example**

Choose \( m = 5 \) and \( n = 2 \).

\[
\begin{align*}
   a &= m^2 - n^2 = 25 - 4 = 21 \\
   b &= 2mn = 2 \times 5 \times 2 = 20 \\
   c &= m^2 + n^2 = 25 + 4 = 29 \\
\end{align*}
\]

**Exercises**

Use the following values of \( m \) and \( n \) to find Pythagorean triples.

1. \( m = 3 \) and \( n = 2 \)
2. \( m = 4 \) and \( n = 1 \)
3. \( m = 5 \) and \( n = 3 \)
4. \( m = 6 \) and \( n = 5 \)
5. \( m = 10 \) and \( n = 7 \)
6. \( m = 8 \) and \( n = 5 \)

   \[
   \begin{align*}
   5, & \ 12, \ 13 \\
   8, & \ 15, \ 17 \\
   15, & \ 30, \ 34 \\
   5, & \ 10, \ 15 \\
   11, & \ 60, \ 61 \\
   51, & \ 140, \ 149 \\
   39, & \ 80, \ 89
   \end{align*}
   \]
10-5 Spreadsheet Activity

Pythagorean Triples

A Pythagorean triple is a set of three whole numbers that satisfies the equation $a^2 + b^2 = c^2$, where $c$ is the greatest number. You can use a spreadsheet to investigate the patterns in Pythagorean triples. A primitive Pythagorean triple is a Pythagorean triple in which the numbers have no common factors other than 1. A family of Pythagorean triples is a primitive Pythagorean triple and its whole number multiples.

The spreadsheet at the right produces a family of Pythagorean triples.

**Step 1** Enter a Pythagorean triple into cells A1, A2, and A3.

**Step 2** Use rows 2 through 10 to find 9 additional Pythagorean triples that are multiples of the primitive triple. Format the rows so that row 2 multiplies the numbers in row 1 by 2, row 3 multiplies the numbers in row 1 by 3, and so on.

The formula in cell A10 is A1 * 10.

## Exercises

Use the spreadsheet of families of Pythagorean triples.

1. Choose one of the triples other than (3, 4, 5) from the spreadsheet. Verify that it is a Pythagorean triple. Sample answer: For (6, 8, 10), $6^2 + 8^2 = 36 + 64 = 100 = 10^2$.

2. Two polygons are similar if they are the same shape, but not necessarily the same size. For triangles, if two triangles have angles with the same measures then they are similar. Use a centimeter ruler to draw triangles with measures from the spreadsheet. Do the triangles appear to be similar? See students’ work.; yes

Each of the following is a primitive Pythagorean triple. Use the spreadsheet to find two Pythagorean triples in their families.

3. (5, 12, 13) Sample answer: (10, 24, 26), (15, 36, 39)

4. (9, 40, 41) Sample answer: (18, 80, 82), (27, 120, 123)

5. (20, 21, 29) Sample answer: (40, 42, 58), (60, 63, 87)

10-6 Study Guide and Intervention

The Distance and Midpoint Formulas

**Distance Formula** The Pythagorean Theorem can be used to derive the Distance Formula shown below. The Distance Formula can then be used to find the distance between any two points in the coordinate plane.

\[ d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \]

**Example 1** Find the distance between the points at $(-5, 2)$ and $(4, 5)$.

\[ d = \sqrt{(4 - (-5))^2 + (5 - 2)^2} = \sqrt{9^2 + 3^2} = \sqrt{81 + 9} = 9 \]

The distance is 90, or about 9.49 units.

**Example 2** Jill draws a line segment from point (1, 4) on her computer screen to point (98, 49). How long is the segment?

\[ d = \sqrt{(98 - 1)^2 + (49 - 4)^2} = \sqrt{97^2 + 45^2} = \sqrt{9409 + 2025} = \sqrt{11434} \]

The segment is about 106.93 units long.

**Exercises**

Find the distance between the points with the given coordinates.

1. (1, 5), (3, 1) \hspace{1cm} 2. (0, 0), (6, 8) \hspace{1cm} 3. (-2, -8), (7, -3)

2 5; 4.47 \hspace{1cm} 2 \sqrt{5}; \hspace{1cm} 5 \hspace{1cm} 3 \sqrt{5}; \hspace{1cm} 6 \hspace{1cm} \frac{5}{2}

4.6; \hspace{1cm} 8 \hspace{1cm} 9 \hspace{1cm} \frac{7}{2} \hspace{1cm} 10 \hspace{1cm} \frac{3}{2} \hspace{1cm} \frac{5}{2}

17 \hspace{1cm} 2 \sqrt{5}; \hspace{1cm} 3 \sqrt{5}; \hspace{1cm} 2 \sqrt{5}; \hspace{1cm} 2 \sqrt{5}; \hspace{1cm} 2 \sqrt{5}; \hspace{1cm} \sqrt{173}; \hspace{1cm} 13.15

Find the possible values of $a$ if the points with the given coordinates are the indicated distance apart.

13. (1, a), (3, -2); $d = \sqrt{5}$ \hspace{1cm} 14. (0, 0), (a, 4); $d = 5$ \hspace{1cm} 15. (2, -1), (a, 3); $d = 5$

-1 or -3 \hspace{1cm} 3 or -3 \hspace{1cm} -1 or 5

16. (1, -3), (2, 21); $d = 25$ \hspace{1cm} 17. (1, a), (-2, 4); $d = 3$ \hspace{1cm} 18. (3, -4), (-4, a); $d = \sqrt{65}$

-6 or 8 \hspace{1cm} 4 \hspace{1cm} -8 or 0
The Distance and Midpoint Formulas

10-6 Study Guide and Intervention (continued)

The point that is equidistance from both of the endpoints is called the midpoint. You can find the coordinates of the midpoint by using the Midpoint Formula.

Midpoint Formula

\[
M = \left( \frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2} \right)
\]

Example 1

Find the coordinates of the midpoint of the segment with endpoints at \((-2, 5)\) and \((4, 9)\).

\[
M = \left( \frac{-2 + 4}{2}, \frac{5 + 9}{2} \right) = \left( 1, \frac{14}{2} \right)
\]

Exercises

Find the coordinates of the midpoint of the segment with the given endpoints.

1. \((1, 6), (3, 10)\)
2. \((2, 8)\)
3. \((-1, 8)\)
4. \((1, 0), (0, 6)\)
5. \((2, -3), (5, -11)\)
6. \((1, -7), (5, -6)\)
7. \((4, -3), (-2, 3)\)
8. \((6, -4), (5, 3)\)
9. \((1, 9), (7, 1)\)
10. \((1, 4), (-3, 12)\)

Find the possible values of \(a\) if the points with the given coordinates are the indicated distance apart.

9. \((-2, -5), (a, 7); \quad d = 13 \quad a = -7 \text{ or } 3\)
10. \((8, -2), (5, a); \quad d = 3 \quad a = -2\)
11. \((4, a), (1, 6); \quad d = 5 \quad a = 2 \text{ or } 10\)
12. \((a, 3), (5, -1); \quad d = 5 \quad a = 2 \text{ or } 8\)
13. \((1, 1), (a, 1); \quad d = 4 \quad a = -3 \text{ or } 5\)
14. \((2, a), (2, 3); \quad d = 10 \quad a = -7 \text{ or } 13\)
15. \((a, 2), (-3, 3); \quad d = \sqrt{2} \quad a = -4 \text{ or } -2\)
16. \((-5, 3), (-3, a); \quad d = \sqrt{5} \quad a = 2 \text{ or } 4\)

Find the coordinates of the midpoint of the segment with the given endpoints.

17. \((-3, 4), (-2, 8); \quad (-2.5, 6)\)
18. \((5, -6), (7, -9); \quad (6, -7.5)\)
19. \((4, 2), (8, 6); \quad (6, 4)\)
20. \((5, 2), (3, 10); \quad (4, 6)\)
21. \((12, -1), (4, -11); \quad (8, -6)\)
22. \((-3, -1), (-11, 3); \quad (-7, 1)\)
23. \((9, 3), (6, -6); \quad (7.5, -1.5)\)
24. \((0, -4), (8, 4); \quad (4, 0)\)
**10-6 Practice**

**The Distance and Midpoint Formulas**

**Find the distance between the points with the given coordinates.**

1. \((4, 7), (1, 3)\) \[5\] 2. \((0, 9), (-7, -2)\) \[\sqrt{170} \approx 13.04\]

3. \((6, 2), \biggl(4, \frac{2}{3}\biggr)\) 5 units or 2.50

4. \((-1, 7), \biggl(\frac{5}{6}\biggr)\) \[\frac{5}{2} \approx 2.50\]

**Find the possible values of \(a\) if the points with the given coordinates are the indicated distance apart.**

5. \((9, -7), (a, -4)\) \[d = \sqrt{18} \quad a = 3\] or 9

6. \((4, 2), (a, -4)\) \[d = \sqrt{250} \quad a = -5\] or -3

7. \((8, -5), (a, 4)\) \[d = \sqrt{85} \quad a = 6\] or 10

8. \((2, 1), (a, -1)\) \[d = \sqrt{29} \quad a = -14\] or -4

**Find the coordinates of the midpoint of the segment with the given endpoints.**

9. \((4, -6), (3, -9)\) \[\biggl(\frac{7}{2}, -\frac{15}{2}\biggr)\]

10. \((0, -4), (3, 2)\) \[\biggl(\frac{3}{2}, -1\biggr)\]

11. \((-2, 3), \biggl(1, \frac{3}{2}\biggr)\) \[\biggl(\frac{5}{2}, \frac{9}{2}\biggr)\]

12. \((-1, 3), \biggl(-\frac{1}{2}, 0\biggr)\) \[\biggl(-\frac{3}{2}, \frac{3}{2}\biggr)\]

**10-6 Word Problem Practice**

**The Distance and Midpoint Formulas**

1. **CHESS** Margaret’s last two remaining chess pieces are located at the centers of the squares opposite corners of the board. If the chessboard is a square with 8-inch sides, about how far apart are the pieces? Round your answer to the nearest tenth. 9.9 in.

2. **ENGINEERING** Todd has drawn a cul-de-sac for a residential development plan. He used a compass to draw the cul-de-sac so that it would be circular. On his blueprint, the center of the cul-de-sac has coordinates \((-1, -1)\) and a point on the circle is \((2, 3)\). What is the radius of the cul-de-sac? 5 units

3. **LANDSCAPING** Randy plotted a triangular patio on a landscape plan for a client. What is the length of fencing he will need along the patio edge that borders the property line? Round your answer to the nearest tenth. 7.1 m

   a. How far is the drum major from the tuba player who dots the “i”? 12.4 yd

   b. Carol is the band member at the top left of the first O in Oklahoma. She is located at (0, 26). How far away is Carol from the tuba player? Round your answer to the nearest tenth. 23.9 yd

4. **UTILITIES** The electric company is running some wires across an open field. The wire connects a utility pole at \((2, 14)\) and a second utility pole at \((7, -8)\). If the electric company wishes to place a third pole at the midpoint of the two poles, at what coordinates should the pole be placed? \((4.5, 3)\)

5. **MARCHING BAND** The Ohio State University marching band performs a famous on-field spelling of O-H-I-O called “Script Ohio”. Sometimes they must fit it into the limited guest band performance area. The diagram below shows part of the adjusted drill chart. Each point represents one band member, and the coordinates are in yards.
A Space-Saving Method

Two arrangements for cookies on a 32 cm by 40 cm cookie sheet are shown at the right. The cookies have 8-cm diameters after they are baked. The centers of the cookies are on the vertices of squares in the top arrangement. In the other, the centers are on the vertices of equilateral triangles. Which arrangement is more economical? The triangle arrangement is more economical, because it contains one more cookie.

In the square arrangement, rows are placed every 8 cm. At what intervals are rows placed in the triangle arrangement?

Look at the right triangle labeled $a$, $b$, and $c$. A leg $a$ of the triangle is the radius of a cookie, or 4 cm. The hypotenuse $c$ is the sum of two radii, or 8 cm. Use the Pythagorean theorem to find $b$, the interval of the rows.

\[
c^2 = a^2 + b^2
\]
\[
8^2 = 4^2 + b^2
\]
\[
64 - 16 = b^2
\]
\[
4\sqrt{3} = b
\]
\[
b = 4\sqrt{3} \approx 6.93
\]

The rows are placed approximately every 6.93 cm.

Solve each problem.

1. Suppose cookies with 10-cm diameters are arranged in the triangular pattern shown above. What is the interval $b$ of the rows? 8.66 cm

2. Find the diameter of a cookie if the rows are placed in the triangular pattern every $\sqrt{3} \text{ cm}$. 6 cm

3. Describe other practical applications in which this kind of triangular pattern can be used to economize on space.

Sample answer: packaging cans

Exercise

Determine whether each pair of triangles is similar. Justify your answer.

1. Yes; corresponding angles have equal measures.
2. No; corresponding angles do not have equal measures.
3. Yes; corresponding angles have equal measures.
4. Yes; corresponding angles have equal measures.
5. Yes; corresponding angles have equal measures.
6. No; corresponding angles do not have equal measures.
**10-7 Study Guide and Intervention (continued)**

**Similar Triangles**

**Find Unknown Measures** If some of the measurements are known, proportions can be used to find the measures of the other sides of similar triangles.

**Example**

**INDIRECT MEASUREMENT**

\[ \triangle ABC \sim \triangle AED \] in the figure at the right. Find the height of the apartment building.

Let \( BC = x \).

\[
\begin{align*}
ED &= AD \\
BC &= AC \\
\frac{7}{x} &= \frac{25}{300} \\
7x &= 25 \\
x &= \frac{25}{7} \\
x &= \frac{2500}{7} \\
x &= 357.14
\end{align*}
\]

The apartment building is 84 meters high.

**Exercises**

Find the missing measures for the pair of similar triangles if \( \triangle ABC \sim \triangle DEF \).

1. \( c = 15, d = 8, e = 6, f = 10 \) \( a = 12; b = 9 \)
2. \( c = 20, a = 12, b = 8, f = 15 \) \( d = 9; e = 6 \)
3. \( a = 8, d = 8, e = 6, f = 7 \) \( b = 6; c = 7 \)
4. \( a = 20, d = 10, e = 8, f = 10 \) \( b = 16; c = 20 \)
5. \( c = 5, d = 10, e = 8, f = 8 \) \( a = \frac{20}{4}; b = 5 \)
6. \( a = 25, b = 20, c = 15, f = 12 \) \( d = 20; e = 16 \)
7. \( b = 8, a = 8, e = 4, f = 10 \) \( a = 16; b = 20 \)

8. **INDIRECT MEASUREMENT**

Bruce likes to amuse his brother by shining a flashlight on his hand and making a shadow on the wall. How far is it from the flashlight to the wall? 51.6 in. or 4.3 ft

9. **INDIRECT MEASUREMENT**

A forest ranger uses similar triangles to find the height of a tree. Find the height of the tree. 60 ft

---

**10-7 Skills Practice**

**Similar Triangles**

Determine whether each pair of triangles is similar. Justify your answer.

1. 
   
   Yes; \( \angle A = \angle D = 90^\circ; \angle B = 180^\circ - (90^\circ + 40^\circ) = 50^\circ \triangle E \); \( \angle F = 180^\circ - (90^\circ + 50^\circ) = 40^\circ \triangle C \). Since the corresponding angles have equal measures, \( \triangle ABC \sim \triangle DEF \).

2. 
   
   No; \( \angle Y = 180^\circ - (60^\circ + 60^\circ) = 60^\circ \). Since \( \triangle UVW \) has a 57° angle, but \( \triangle XYZ \) does not, corresponding angles do not all have equal measures, and the triangles are not similar.

3. 
   
   No; \( \angle F = 180^\circ - (45^\circ + 40^\circ) = 95^\circ \). Since \( \triangle HJK \) has a 90° angle, but \( \triangle EFG \) does not, corresponding angles do not all have equal measures, and the triangles are not similar.

4. 
   
   Yes; \( \angle G = 180^\circ - (65^\circ + 52^\circ) = 63^\circ = \angle LK \); \( \angle J = 180^\circ - (63^\circ + 52^\circ) = 65^\circ = \angle LF \); \( \angle E = \angle H = 52^\circ \). Since the corresponding angles have equal measures, \( \triangle EFG \sim \triangle HJK \).

Find the missing measures for the pair of similar triangles if \( \triangle PQR \sim \triangle STU \).

5. \( r = 4, s = 6, t = 3, u = 2 \) \( p = 12, q = 6 \)
6. \( t = 8, p = 21, q = 14, r = 7 \) \( u = 4, s = 12 \)
7. \( p = 15, q = 10, r = 5, s = 6 \) \( f = 4, u = 2 \)
8. \( p = 48, s = 16, t = 8, u = 4 \) \( r = 12, q = 24 \)
9. \( q = 6, s = 2, t = \frac{3}{2}, r = \frac{1}{2} \) \( p = 2, \theta = 8 \)
10. \( p = 3, q = 2, r = 1, u = \frac{1}{3} \) \( s = 1, \theta = \frac{2}{3} \)
11. \( p = 14, q = 7, u = 2.5, t = 5 \) \( r = 3.5, s = 10 \)
12. \( r = 6, s = 3, t = \frac{23}{8} \) \( p = 8, q = 7 \)
10-7 Practice

**Similar Triangles**

Determine whether each pair of triangles is similar. Justify your answer.

1. Yes; \( \angle Q = \angle T = 90^\circ; \angle P = 180^\circ - (90^\circ + 31^\circ) = 59^\circ = \angle S; \angle U = 180^\circ - (90^\circ + 59^\circ) = 31^\circ = \angle R. \) Since the corresponding angles have equal measures, \( \triangle PQR \sim \triangle STU. \)

2. No; \( \angle C = 180^\circ - (47^\circ + 80^\circ) = 53^\circ. \) Since \( \triangle FGH \) has a 56° angle, but \( \triangle CDE \) does not, corresponding angles do not all have equal measures, and the triangles are not similar.

Find the missing measures for the pair of similar triangles if \( \triangle ABC \sim \triangle DEF. \)

3. \( c = 4, d = 12, e = 16, f = 8 \) \( a = 6, b = 8 \)

4. \( e = 20, a = 24, b = 30, c = 15 \) \( d = 16, f = 10 \)

5. \( a = 10, b = 12, c = 6, d = 4 \) \( e = 4.8, f = 2.4 \)

6. \( a = 4, d = 6, e = 4, f = 3 \) \( c = 2, b = \frac{8}{3} \)

7. \( b = 15, d = 16, e = 20, f = 10 \) \( a = 12, c = \frac{15}{2} \)

8. \( a = 16, b = 22, c = 12, f = 8 \) \( d = \frac{32}{3}, e = \frac{44}{3} \)

9. \( a = \frac{5}{2}, b = 3, f = \frac{11}{2}, e = 7 \) \( c = \frac{33}{14}, d = \frac{35}{6} \)

10. \( c = 4, d = 6, e = 5.625, f = 12 \) \( a = 2, b = 1.875 \)

11. **SHADOWS** Suppose you are standing near a building and you want to know its height. The building casts a 66-foot shadow. You cast a 3-foot shadow. If you are 5 feet 6 inches tall, how tall is the building? 121 ft

12. **MODELS** Truss bridges use triangles in their support beams. Molly made a model of a truss bridge in the scale of 1 inch = 8 feet. If the height of the triangles on the model is 4.5 inches, what is the height of the triangles on the actual bridge? 36 ft

10-7 Word Problem Practice

**Similar Triangles**

1. **CRAFTS** Layla is wants to buy a set of similar magnets for her refrigerator door. Layla finds the magnets below for sale at a local shop. Which two are similar?

   - **B** and **C**

2. **EXHIBITIONS** The world's largest candle was displayed at the 1897 Stockholm Exhibition. Suppose Lars measured the length of the shadow it cast at 11:00 A.M. and found that it was 12 feet. Suppose that immediately after this, he measured to find that a nearby 25-foot tent pole cast a shadow 5 feet long. How tall was the world’s largest candle? 80 ft

3. **LANDMARKS** The Toy and Miniature Museum of Kansas City displays a miniature replica of George Washington’s Mount Vernon mansion. The miniature house is 10 feet long, 6 feet wide, 8 feet tall, and has 22 rooms. The scale of the model to the original is one inch to one foot. If the roof gable of the miniature has dimensions as shown on the diagram below, what is the height of the roof gable on the original Mount Vernon mansion? 14 ft

4. **SURVEYING** Surveyors use properties of triangles including similarity and the Pythagorean Theorem to find unknown distances. Use the dimensions on the diagram to find the unknown distance \( x \) across the lake. 80 m

5. **PUZZLES** The figure below shows an ancient Chinese movable puzzle called a tangram. It has 7 pieces that can be reconfigured to produce an endless number of designs and pictures.

Assume that the side length of this tangram square is \( \sqrt{2} \) cm. Leave your answers as simplified radical expressions.

   - **a.** What are the side lengths of triangles 1 and 2? 1 cm, 1 cm, \( \sqrt{2} \) cm
   - **b.** What are the side lengths of triangle 37? \( \frac{\sqrt{2}}{2} \) cm, \( \frac{\sqrt{2}}{2} \) cm, 1 cm
   - **c.** What are the side lengths of triangles 3 and 5? \( \frac{1}{2} \) cm, \( \frac{1}{2} \) cm, \( -\frac{\sqrt{2}}{2} \) cm
Trigonometric Ratios

1. Use the length of $BC$ and the Pythagorean Theorem to find the length of $AC$.
   
   $AC = \sqrt{1^2 + \left(\frac{7}{8}\right)^2} = 1.3287682$

2. Find the length of $AD$.

   $AD = AC = 1.3287682$

3. Use the length of $\overline{AD}$ and the Pythagorean Theorem to find the length of $AE$.

   $AE = \sqrt{(AD)^2 + \left(\frac{1}{2}\right)^2} = 1.4197271$

4. The sides of the similar triangles $FED$ and $DEA$ are in proportion. So, $\frac{FE}{0.5} = \frac{AE}{AB}$. Find the length of $FE$.

   $FE = \frac{1}{4}(AE) = 0.1760902$

5. Find the length of $AF$.

   $AF = AE - FE = 1.2436369$

6. The sides of the similar triangles $APB$ and $AEG$ are in proportion. So, $\frac{AP}{AE} = \frac{AB}{AG}$. Find the length of $AG$.

   $AG = AB \cdot AE = AF = 1.145929$

7. Now, find the length of $BG$.

   $BG = AG - AB = AG - 1 = 0.145929$

8. The value of $\pi$ to seven decimal places is $3.1415927$. Compare the fractional part of $\pi$ with the length of $BG$.

   $0.145929 - 0.145927 = 0.000002$, an error of less than $1$ part in a million

### Example

Find the values of the three trigonometric ratios for angle $A$.

**Step 1** Use the Pythagorean Theorem to find $BC$.

\[a^2 + b^2 = c^2\]

- $a^2 + 8^2 = 10^2$
- $b - 8$ and $c = 10$
- $a^2 + 64 = 100$
- Simply subtract $64$ from both sides.
- $a = 6$
- Take the square root of each side.

**Step 2** Use the side lengths to write the trigonometric ratios.

\[
\begin{align*}
\sin A &= \frac{opp}{hyp} = \frac{6}{10} = \frac{3}{5} \\
\cos A &= \frac{adj}{hyp} = \frac{8}{10} = \frac{4}{5} \\
\tan A &= \frac{opp}{adj} = \frac{6}{8} = \frac{3}{4}
\end{align*}
\]

### Exercises

Find the values of the three trigonometric ratios for angle $A$.

1. $\sin A = \frac{15}{17}, \cos A = \frac{8}{17}$
2. $\sin A = \frac{7}{25}, \cos A = \frac{24}{25}$
3. $\tan A = \frac{15}{8}, \sin A = \frac{4}{5}, \cos A = \frac{3}{5}, \tan A = \frac{4}{3}$
4. $\tan A = \frac{7}{24}, \sin A = \frac{25}{11}\sqrt{43}$
5. $\cos 25^\circ = 0.9063$
6. $\tan 85^\circ = 11.4301$

Use a calculator to find the value of each trigonometric ratio to the nearest ten-thousandth.
10-8 Study Guide and Intervention (continued)

Trigonometric Ratios

Use Trigonometric Ratios When you find all of the unknown measures of the sides and angles of a right triangle, you are solving the triangle. You can find the missing measures of a right triangle if you know the measure of two sides of the triangle, or the measure of one side and the measure of one acute angle.

Example

Solve the triangle. Round each side length to the nearest tenth.

Step 1 Find the measure of $\angle B$. The sum of the measures of the angles in a triangle is 180.

$180^\circ - (90^\circ + 38^\circ) = 52^\circ$

The measure of $\angle B$ is 52°.

Step 2 Find the measure of $AB$. Because you are given the measure of the side adjacent to $\angle A$ and are finding the measure of the hypotenuse, use the cosine ratio.

$\cos 38^\circ = \frac{13}{c}$

Multiply each side by $c$.

$c \cos 38^\circ = 13$

Divide each side by $\sin 41^\circ$.

$\frac{c}{\cos 38^\circ} = \frac{13}{\sin 41^\circ}$

So the measure of $AB$ is about 16.5.

Step 3 Find the measure of $BC$. Because you are given the measure of the side adjacent to $\angle A$ and are finding the measure of the side opposite $\angle A$, use the tangent ratio.

$\tan 38^\circ = \frac{a}{b}$

Multiply each side by $13$.

$13 \tan 38^\circ = a$

Use a calculator.

$10.2 \approx a$

So the measure of $BC$ is about 10.2.

Exercises

Solve each right triangle. Round each side length to the nearest tenth.

1. $\angle B = 60^\circ$, $AC \approx 7.8$, $BC \approx 4.5$

2. $\angle A = 60^\circ$, $AC \approx 7.7$, $AB \approx 11.1$

3. $\angle B = 34^\circ$, $AC \approx 19.3$, $AB \approx 10.8$

10-8 Skills Practice

Trigonometric Ratios

Find the values of the three trigonometric ratios for angle $A$.

1. $A$

$\sin A = \frac{77}{85}$, $\cos A = \frac{36}{85}$, $\tan A = \frac{77}{36}$

2. $B$

$\sin A = \frac{4}{5}$, $\cos A = \frac{3}{5}$, $\tan A = \frac{4}{3}$

3. $C$

$\sin A = \frac{12}{13}$, $\cos A = \frac{5}{13}$, $\tan A = \frac{12}{5}$

4. $D$

$\sin A = \frac{8}{17}$, $\cos A = \frac{15}{17}$, $\tan A = \frac{8}{15}$

Use a calculator to find the value of each trigonometric ratio to the nearest ten-thousandth.

5. $\sin 18^\circ \approx 0.3090$

6. $\cos 68^\circ \approx 0.3746$

7. $\tan 75^\circ \approx 3.7321$

8. $\sin 9^\circ \approx 0.1564$

Solve each right triangle. Round each side length to the nearest tenth.

9. $\angle A = 73^\circ$, $AB \approx 13.6$, $AC \approx 4.0$

10. $\angle B = 35^\circ$, $AB \approx 10.5$, $BC \approx 8.6$

Find $m \angle J$ for each right triangle to the nearest degree.

11. $L 5 \quad K$

$40^\circ$

12. $L 11 \quad K$

$55^\circ$
10-8 Practice

Trigonometric Ratios

Find the values of the three trigonometric ratios for angle A.

1. \( \sin A = \frac{65}{97}, \cos A = \frac{72}{97}, \tan A = \frac{65}{72} \)

2. \( \sin A = \frac{36}{39}, \cos A = \frac{15}{39}, \tan A = \frac{36}{15} \)

Use a calculator to find the value of each trigonometric ratio to the nearest ten-thousandth.

3. \( \tan 26^\circ \approx 0.4877 \)

4. \( \sin 53^\circ \approx 0.7986 \)

5. \( \cos 81^\circ \approx 0.1564 \)

Solve each right triangle. Round each side length to the nearest tenth.

6. \( \angle B = 23^\circ, AB = 23.9, AC = 9.3 \)

7. \( \angle A = 61^\circ, AB = 10.3, BC = 5.0 \)

Find \( \angle J \) for each right triangle to the nearest degree.

8. \( \angle J = 24^\circ \)

9. \( \angle J = 42^\circ \)

10. SURVEYING If point A is 54 feet from the tree, and the angle between the ground at point A and the top of the tree is 25°, find the height \( h \) of the tree.

\( 25.2 \) ft

10-8 Word Problem Practice

Trigonometric Ratios

1. WASHINGTON MONUMENT Jeannie is trying to determine the height of the Washington Monument. If point A is 765 feet from the monument, and the angle between the ground and the top of the monument at point A is 36°, find the height \( h \) of the monument to the nearest foot. 556 ft

2. AIRPLANES A pilot takes off from a runway at an angle of 20º and maintains that angle until it is at its cruising altitude of 2500 feet. What horizontal distance has the plane traveled when it reaches its cruising altitude? 6869 ft

3. TRUCK RAMPS A moving company uses an 11-foot-long ramp to unload furniture from a truck. If the bed of the truck is 3 feet above the ground, what is the angle of incline of the ramp to the nearest degree? 16°

4. SPECIAL TRIANGLES While investigating right triangle \( KLM \), Mercedes finds that \( \cos M = \sin M \). What is the measure of angle \( M \)? 45°

5. TELEVISIONS Televisions are commonly sized by measuring their diagonal. A common size for widescreen plasma TVs is 42 inches.

\( a. \) A widescreen television has a 16:9 aspect ratio, that is, the screen width is \( \frac{16}{9} \) times the screen height. Use the Pythagorean Theorem to write an equation and solve for the height \( h \) of the television in inches.

\( \left( \frac{16}{9}h \right)^2 + h^2 = 42^2; h = 20.6 \) in.

\( b. \) Use the information from part \( a. \) to solve the right triangle.

width = 36.8 in., \( \angle A = 29^\circ, \angle B = 61^\circ \)

\( c. \) What would the measure of angle \( A \) be on a standard television with a 4:3 aspect ratio? 37°
10-8 Enrichment

More Trigonometric Ratios

In addition to the sine, cosine, and tangent, there are three other common trigonometric ratios. They are the secant, cosecant, and cotangent.

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<th>Trigonometric Ratio</th>
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<td>secant of ( \angle A )</td>
<td>( \frac{\text{hypotenuse}}{\text{adjacent to } \angle A} )</td>
<td>( \text{sec} A = \frac{c}{b} )</td>
</tr>
<tr>
<td>cosecant of ( \angle A )</td>
<td>( \frac{\text{hypotenuse}}{\text{opposite to } \angle A} )</td>
<td>( \text{csc} A = \frac{c}{a} )</td>
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<tr>
<td>cotangent of ( \angle A )</td>
<td>( \frac{\text{adjacent to } \angle A}{\text{opposite to } \angle A} )</td>
<td>( \text{cot} A = \frac{a}{b} )</td>
</tr>
</tbody>
</table>

**Example**

Find the secant, cosecant, and cotangent of angle \( A \).

Use the side lengths to write the trigonometric ratios.

\[
\text{sec} A = \frac{15}{9} = \frac{5}{3} \quad \quad \text{csc} A = \frac{15}{12} = \frac{5}{4} \\
\text{cot} A = \frac{12}{9} = \frac{4}{3}
\]

**Exercises**

Find the secant, cosecant, and cotangent of angle \( A \).

1. \( \text{sec} A = \frac{17}{8} \), \( \text{csc} A = \frac{17}{15} \)
2. \( \text{sec} A = \frac{5}{3} \), \( \text{csc} A = \frac{5}{4} \)
3. \( \text{sec} A = \frac{25}{24} \), \( \text{csc} A = \frac{25}{27} \)
4. \( \text{cot} A = \frac{8}{5} \)

4. How does the sine of an angle relate to the angle’s cosecant? How does the cosine of an angle relate to the angle’s secant? How does the cotangent of an angle relate to the angle’s secant?

\[
\text{sec} A = \frac{1}{\cos A}, \quad \text{csc} A = \frac{1}{\sin A}, \quad \text{and} \quad \text{cot} A = \frac{1}{\tan A}
\]

Use the relations that you found in Exercise 4 and a calculator to find the value of each trigonometric ratio to the nearest ten-thousandth.

5. \( \text{sec} 17^\circ \approx 1.0457 \)
6. \( \text{csc} 49^\circ \approx 1.3250 \)
7. \( \text{cot} 81^\circ \approx 0.1584 \)
Chapter 10 Assessment Answer Key

Quiz 1 (Lessons 10-1 and 10-2)
Page 57

1. \[ D = \{x|x \geq -1\}; \]
2. \[ A \]
3. \[ 6\sqrt{2} \]
4. \[ 2|x|\sqrt{2y} \]
5. \[ \frac{12 - 3\sqrt{2}}{14} \]

Quiz 2 (Lesson 10-3)
Page 57

1. \[ 26\sqrt{5} \]
2. \[ 4\sqrt{6} + 8\sqrt{10} \]
3. \[ 5\sqrt{2} + 6\sqrt{5} \]
4. \[ \sqrt{15} - 2\sqrt{2} \]
5. \[ D \]
6. \[ 5 \]
7. \[ D \]

Quiz 3 (Lessons 10-4 and 10-5)
Page 58

1. \[ 14.70 \]
2. \[ \text{no} \]
3. \[ C \]
4. \[ \sqrt{61} \text{ or } 7.81 \]
5. \[ (-4, 8) \]

Quiz 4 (Lesson 10-6)
Page 58

1. \[ \text{Yes, since corresponding angles have equal measures.} \]
2. \[ b = 21, z = 10 \]
3. \[ 39 \text{ ft} \]
4. \[ A \]
5. \[ RP = 27.5, \]
6. \[ PQ = 29.2, \]
7. \[ m\angle Q = 70^\circ \]
8. \[ 6\sqrt{5} - 20\sqrt{3} \]
9. \[ 23 \]
10. \[ 30\sqrt{2} \]
11. \[ 7\sqrt{5} - 2\sqrt{10} \]
12. \[ 3\sqrt{2} + 2\sqrt{6} \]
13. \[ 5 \]
14. \[ 29 \]
15. \[ 9.49 \text{ ft} \]
# Chapter 10 Assessment Answer Key

## Vocabulary Test

**Form 1**

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<td>9. similar triangles</td>
<td>B</td>
<td>B: (</td>
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</tbody>
</table>

**Sample answer:** the study of relationships among the angles and sides of the triangle.

**Sample answer:** the trigonometric ratio equivalent to the leg opposite to an angle divided by the leg adjacent to the angle.
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<td>5. C</td>
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</tr>
<tr>
<td>8. G</td>
<td>20. C</td>
</tr>
<tr>
<td>B: 12 m</td>
<td></td>
</tr>
<tr>
<td>B: 14 ft</td>
<td></td>
</tr>
</tbody>
</table>

Chapter 10 Assessment Answer Key
Chapter 10 Assessment Answer Key

Form 2C
Page 67
1. D = \{x \mid x \geq 2\};
   R = \{y \mid y \geq 1\}

2. \(6\sqrt{2}\)

3. \(5y^2|w|\sqrt{3}w\)

4. \(3\sqrt{2} + 2\sqrt{3}\)

5. \(20\sqrt{5}\)

6. \(2\sqrt{14} + 5\sqrt{3}\)

7. \((-1, 2)\)

8. 12

9. 11

10. 12

11. 11.66

12. 7

13. yes

14. no

15. \(\sqrt{61}\) or 7.81

16. \(\sqrt{185}\) or 13.60

17. \(\sqrt{185}\) or 13.60

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18. Yes, since corresponding angles have equal measures.

19. No, not all corresponding angles have equal measures.

20. \(c = \frac{14}{3}, u = 6\)

21. \(40\frac{1}{2}\) ft

22. \(\sqrt{149}\) mi or 12.2 mi

23. \(\approx 12.5\) cm

24. \(67^\circ\)

25. \(\approx 23.2\) ft

B: \(-2\)
Chapter 10 Assessment Answer Key

Form 2D
Page 69

1. \( R = \{x \mid x \geq -1\}; \)
   \( D = \{y \mid y \geq -3\} \)
   \( R = \{x \mid x \geq -2\}; \)
   \( D = \{y \mid y \leq -1\} \)

2. 

3. \( 10\sqrt{2} \)

4. \( 5|x y|\sqrt{2x} \)

5. \( 10\sqrt{5} + 15\sqrt{2} \)

6. \( 2\sqrt{y} \)

7. \( 22\sqrt{6} \)

8. \( 4 \)

9. \( 3 \)

10. \( 4 \)

11. \( 8.06 \)

12. \( 8 \)

13. yes

14. no

15. \( \sqrt{74} \) or 8.60

16. \( \sqrt{193} \) or 13.89

17. \( (3, 2) \)

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18. 

Yes, since corresponding angles have equal measures.

19. 

\( a = \frac{27}{7}, y = 10 \)

20. 

15 ft

21. 

5.39 mi

22. 

15.20 cm

23. 

69°

24. 

\( \approx 30.0 \) ft

B: \( -3 \)
Chapter 10 Assessment Answer Key

Form 3
Page 71

1. \[ D = \{ x \mid x \geq 2 \}; \]
   \[ R = \{ y \mid y \leq -2 \} \]

2. \[ D = \{ x \mid x \geq -4 \}; \]
   \[ R = \{ y \mid y \leq -12 \} \]

3. \[ 18\sqrt{7} \]

4. \[ \frac{x^2\sqrt{5n}}{2n^3} \]

5. \[ \frac{2\sqrt{10} - \sqrt{3}}{7} \]

6. \[ 0 \]

7. \[ 40\sqrt{2} - 27\sqrt{15} \]

8. \[ 6 \]

9. no solution

10. \[ \frac{7}{2}, 5 \]

11. \[ \sqrt{41} \]

12. \[ 2\sqrt{11} \text{ cm} \]

13. no

14. yes

15. \[ 7\sqrt{5} \text{ or } 15.65 \]

16. \[ 4 \]

17. \[ 20\sqrt{5} \text{ units} \]

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18. No, not all corresponding angles have equal measures.

19. Yes, since corresponding angles have equal measures.

20. \( b = 1.6, z = 5.355 \)

21. \( 136\frac{1}{2} \text{ m} \)

22. \( 10.20 \text{ cm} \)

23. \( 8.06 \text{ miles} \)

24. \( 54^\circ \)

25. \( 87.0 \text{ ft} \)

B: \[ \frac{7\sqrt{30} - 27}{39} \]
# Chapter 10 Assessment Answer Key

## Page 73, Extended-Response Test

### Scoring Rubric

<table>
<thead>
<tr>
<th>Score</th>
<th>General Description</th>
<th>Specific Criteria</th>
</tr>
</thead>
</table>
| 4     | Superior            | • Shows thorough understanding of the concepts of simplifying radical expressions, solving radical equations, the Pythagorean Theorem, right triangles, similar triangles, and the distance formula.  
• Uses appropriate strategies to solve problems.  
• Computations are correct.  
• Written explanations are exemplary.  
• Graphs are accurate and appropriate.  
• Goes beyond requirements of some or all problems. |
| 3     | Satisfactory        | • Shows an understanding of the concepts of simplifying radical expressions, solving radical equations, the Pythagorean Theorem, right triangles, similar triangles, and the distance formula.  
• Uses appropriate strategies to solve problems.  
• Computations are mostly correct.  
• Written explanations are effective.  
• Graphs are mostly accurate and appropriate.  
• Satisfies all requirements of problems. |
| 2     | Nearly Satisfactory | • Shows an understanding of most of the concepts of simplifying radical expressions, solving radical equations, the Pythagorean Theorem, right triangles, similar triangles, and the distance formula.  
• May not use appropriate strategies to solve problems.  
• Computations are mostly correct.  
• Written explanations are satisfactory.  
• Graphs are mostly accurate.  
• Satisfies the requirements of most of the problems. |
| 1     | Nearly Unsatisfactory | • Final computation is correct.  
• No written explanations or work is shown to substantiate the final computation.  
• Graphs may be accurate but lack detail or explanation.  
• Satisfies minimal requirements of some of the problems. |
| 0     | Unsatisfactory      | • Shows little or no understanding of most of the concepts of simplifying radical expressions, solving radical equations, the Pythagorean Theorem, right triangles, similar triangles, and the distance formula.  
• Does not use appropriate strategies to solve problems.  
• Computations are incorrect.  
• Written explanations are unsatisfactory.  
• Graphs are inaccurate or inappropriate.  
• Does not satisfy requirements of problems.  
• No answer may be given. |
Chapter 10 Assessment Answer Key

Page 73, Extended-Response Test
Sample Answers

In addition to the scoring rubric found on page A30, the following sample answers may be used as guidance in evaluating extended-response assessment items.

1a. The Product Property of Square Roots states that the square root of a product is equal to the product of the square roots of the factors. For this property, \(a \geq 0\) and \(b \geq 0\).

1b. The Quotient Property of Square Roots states that the square root of a quotient is equal to the quotient of the square roots of the numerator and denominator. For this property, \(a \geq 0\) and \(b > 0\).

1c. The student should recognize that both properties state that finding a square root can be done before or after certain other operations.

2a. \(P = \frac{L^2}{k}\)

2b. Sample answer:

<table>
<thead>
<tr>
<th>(L)</th>
<th>25</th>
<th>50</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P)</td>
<td>5208</td>
<td>20,833</td>
<td>46,875</td>
</tr>
</tbody>
</table>

2c. Sample answer:

<table>
<thead>
<tr>
<th>(L)</th>
<th>25</th>
<th>50</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P)</td>
<td>7813</td>
<td>31,250</td>
<td>70,313</td>
</tr>
</tbody>
</table>

2d. A smaller constant of proportionality allows a plane to carry more weight.

3a. The student should agree. Since the measures of the three angles in a triangle have a sum of 180°, having two pairs of corresponding angles equal in measure forces the third pair of corresponding angles to also be equal in measure. Thus, by definition the two triangles must be similar.

3b. The student should disagree. Although two triangles that are the same size and same shape will have two pairs of sides equal in measure, having two pairs of sides equal in measure does not guarantee that corresponding sides are proportional. The two right triangles with side lengths of 3, 4, 5, and 4, 5, \(\sqrt{41}\) respectively are an example.

4a. Sample answer: \(a = 9, b = 8\); Using the Distance Formula, \(AB = \sqrt{145}\), \(AC = 8, BC = 9\).

4b. Sample answer: \(a = 9, b = 8\).

\((\sqrt{145})^2 \neq 9^2 + 8^2\)

\(145 = 81 + 64\)
Chapter 10 Assessment Answer Key

Standardized Test Practice

Page 74

1. ◦ ◦ ◦ ◦

2. ◦ ◦ ◦ ◦

3. ◦ ◦ ◦ ◦

4. ◦ ◦ ◦ ◦

5. ◦ ◦ ◦ ◦

6. ◦ ◦ ◦ ◦

7. ◦ ◦ ◦ ◦

8. ◦ ◦ ◦ ◦

9. ◦ ◦ ◦ ◦

10. ◦ ◦ ◦ ◦

11. ◦ ◦ ◦ ◦

12. ◦ ◦ ◦ ◦

13. ◦ ◦ ◦ ◦

14. ◦ ◦ ◦ ◦

15. ◦ ◦ ◦ ◦

16. ◦ ◦ ◦ ◦

17. ◦ ◦ ◦ ◦

18. ◦ ◦ ◦ ◦

19. ◦ ◦ ◦ ◦
Chapter 10 Assessment Answer Key

Standardized Test Practice
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20. $10,800 at 14%,
21. $1200 at 10%
22. \(y = -5x + 14\)
23. \(\{w \mid w \leq -1 \text{ or } w > 2\}\)
24. No solution
25. \(\frac{3h^6k^2}{-2j^{10}}\)
26. \(\frac{18abc^2}{-15 \text{ and } -17 \text{ or } 15 \text{ and } 17}\)
27. \(-4.4, -11.6\)
28. \$3648.08
29. 14.2 mi
30a. 7.2 mi