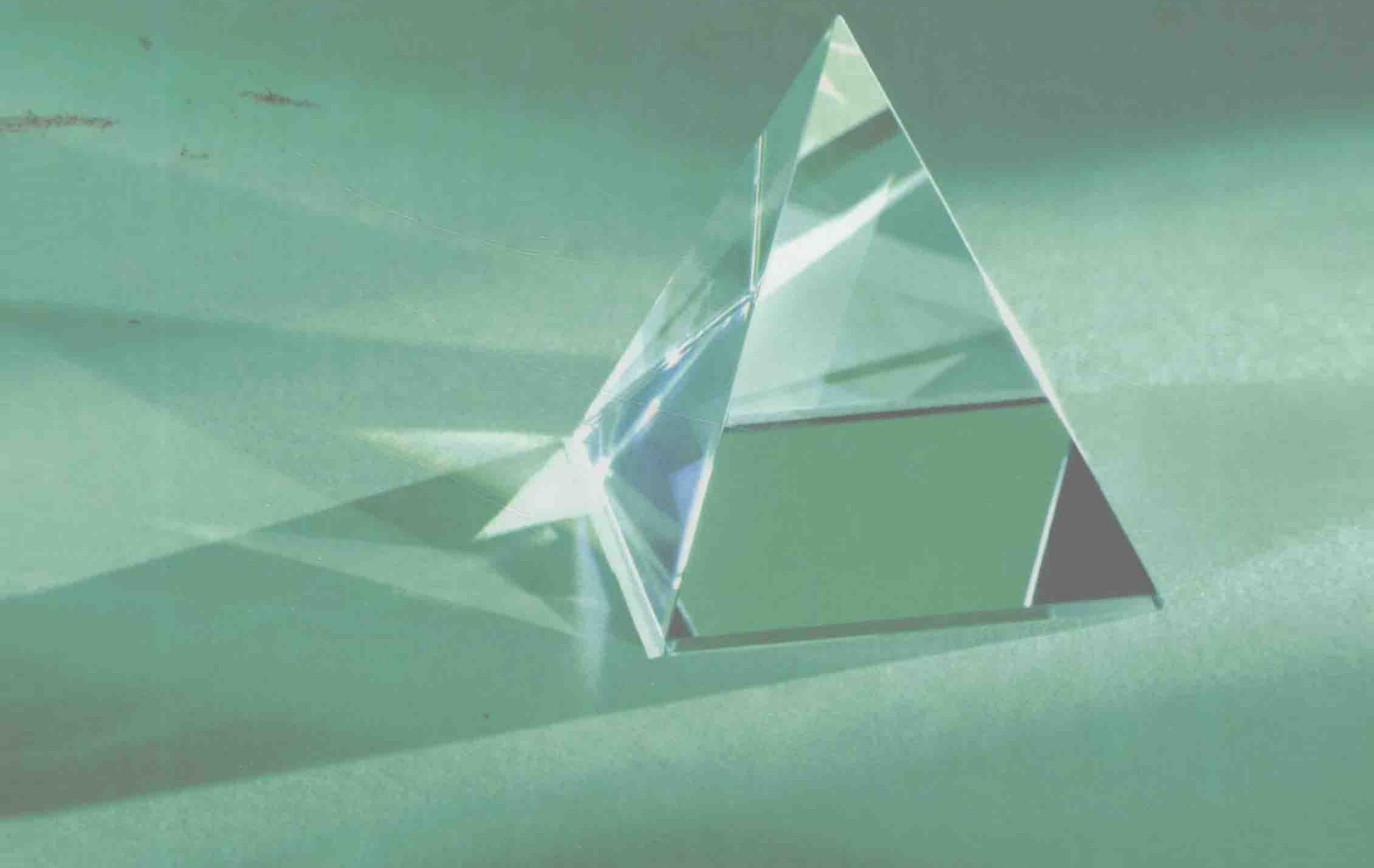
Instructor's Annotated Edition

TRIGONOMETRY

LARSON / HOSTETLER



SIXTH EDITION

Instructor's Annotated Edition

Trigonometry

Sixth Edition

- **Ron Larson**
- **Robert P. Hostetler**

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The Behrend College

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The Pennsylvania State University
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A Word from the Authors

Welcome to *Trigonometry*, Sixth Edition. In this revision we continue to focus on promoting student success, while providing an accessible text that offers flexible teaching and learning options.

In keeping with our philosophy that students learn best when they know what they are expected to learn, we have retained the thematic study thread from the Fifth Edition. We first introduce this study thread in the Chapter Opener. Each chapter begins with a study guide that contains a comprehensive overview of the chapter concepts (*What you should learn*), a list of *Important Vocabulary* integral to learning the chapter concepts, a list of additional chapter-specific *Study Tools*, and additional text-specific resources. The study guide allows students to get organized and prepare for the chapter. Then, each section opens with a a set of learning objectives outlining the concepts and skills students are expected to learn (*What you should learn)*, followed by an interesting real-life application used to illustrate why it is important to learn the concepts in that section (*Why you should learn it*). *Study Tips* at point-of-use provide support as students read through the section. And finally, to provide study support and a comprehensive review of the chapter, each chapter concludes with a chapter summary (*What did you learn?*), which reinforces the section objectives, and chapter *Review Exercises*, which are correlated to the chapter summary.

In addition to providing in-text study support, we have taken care to write a text for the student. We paid careful attention to the presentation, using precise mathematical language and clear writing, to create an effective learning tool. We are committed to providing a text that makes the mathematics within it accessible to all students. In the Sixth Edition, we have revised and improved upon many text features designed for this purpose. The *Technology*, *Exploration* features have been expanded. *Chapter Tests*, which gave students an opportunity for self-assessment, are included in every chapter. We have retained the *Synthesis* exercises, which check students' conceptual understanding, and the *Review* exercises, which reinforce skills learned in previous sections within each section exercise set. Also, students have access to several media resources that offer additional text-specific resources to enhance the learning process.

From the time we first began writing in the early 1970s, we have always viewed part of our authoring role as that of providing instructors with flexible teaching programs. The optional features within the text allow instructors with different pedagogical approaches to design their course to meet both their instructional needs and the needs of their students. Instructors who stress applications and problem solving, or exploration and technology, and more traditional methods will be able to use this text successfully. We hope you enjoy the Sixth Edition.

Ron Larson

Robert P. Hostetler

Acknowledgments

We would like to thank the many people who helped us at various stages of this project. Their encouragement, criticisms, and suggestions have been invaluable to us.

Sixth Edition Reviewers

Ahmad Abusaid, Southern Polytechnic University; Catherine Banks, Texas Woman's College; Jared Burch, College of the Sequoias; Dr. Michelle R. DeDeo, University of North Florida; Gangadhar R. Hiremath, Miles College; Dr. Kevin W. Hopkins, Southwest Baptist University; Charles W. Johnson, South Georgia College; Gary S. Kersting, North Central Michigan College; Namyong Lee, Minnesota State University; Mary Leeseberg, Manatee Community College; Tristan Londré, Blue River Community College; Bruce N. Lundberg, University of Southern Colorado; Rudy Maglio, Oakton Community College; Steve O'Donnell, Rogue Community College; Armando I. Perez, Laredo Community College; Rita Randolfi, Brevard Community College; David Ray, The University of Tennessee at Martin; Miguel San Miguel Gonzalez, Texas A&M International University; Scott Satake, North Idaho College; Jed Soifer, Atlantic Cape Community College; Dr. Roy N. Tucker, Palo Alto College and The University of Texas at San Antonio; Karen Villarreal, Xavier University of Louisiana; Carol Walker, Hinds Community College; J. Lewis Walston, Methodist College; Jun Wang, Alabama State University; Ibrahim Wazir, American International School; Robert Wylie, Carl Albert State College

We would like to extend a special thanks to all of the instructors who took time to participate in our phone interviews.

We would like to thank the staff of Larson Texts, Inc. and the staff of Meridian Creative Group, who assisted in proofreading the manuscript, preparing and proofreading the art package, and typesetting the supplements.

We are grateful to our wives, Deanna Gilbert Larson and Eloise Hostetler, for their love, patience, and support. Also, a special thanks goes to R. Scott O'Neil.

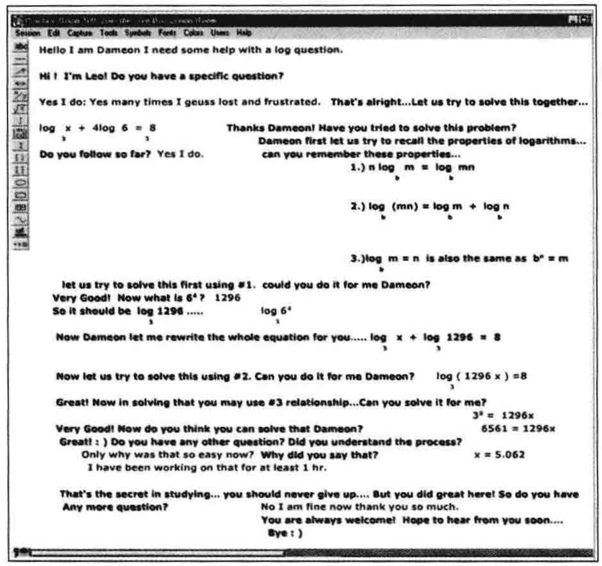
If you have suggestions for improving this text, please feel free to write to us. Over the years we have received many useful comments from both instructors and students, and we value these comments very much.

Ron Larson
Robert P. Hostetler

How can this book help you

Support for Student Success

- Larson provides clear, easy-to-read examples that include all the steps needed to understand a new concept.
- Numerous examples are provided throughout the book that correspond to the exercise sets, giving students support with the key concepts in their homework assignments.
- Additional resources are also available, such as SMARTHINKING's live, one-on-one online tutoring service. This enables students to receive tutorial help from the comfort and privacy of their own home.
- Key course material is also presented on a DVD by a qualified instructor, making it easy to review content or material missed due to an absence.



Options for Students and Instructors

- Concepts are presented through examples, applications, technology, or explorations to adapt the course to the curriculum needs or student learning styles.
- A variety of exercises that increase in difficulty allows professors the flexibility to assign homework to students with various learning styles. Exercise options include skills, technology, critical thinking, writing, applications, modeling data, true/false, proofs, and theoretical questions.
- The P.S. Problem Solving section at the end of every chapter offers more challenging exercises for advanced students.
- This text provides a solid mathematical foundation by foreshadowing concepts that will be used in future courses. Topics that will be especially helpful to students in Calculus are labeled with an "Algebra of Calculus" ∫ icon.

Exploration

Graph each of the functions with a graphing utility. Determine whether the function is *even*, *odd*, or *neither*.

Technology

You can use a graphing utility to determine the domain of a composition of functions. For the composition in Example 5, enter the function

▸ Proofs in Mathematics 73

Proofs in Mathematics

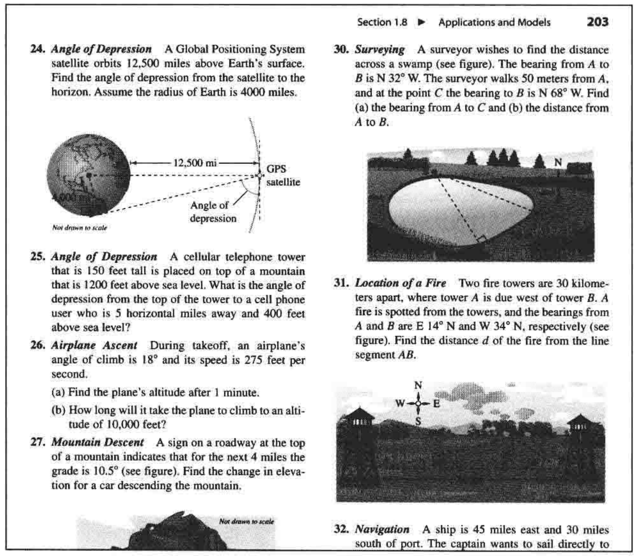
What does the word *proof* mean to you? In mathematics, the word *proof* is used to mean simply a valid argument. When you are proving a statement or theorem, you must use facts, definitions, and accepted properties in a logical order. You can also use previously proved theorems in your proof. For instance, the Distance Formula is used in the proof of the Midpoint Formula below. There are several different proof methods, which you will see in later chapters.

succeed in your math course?

For more information, see pages xii–xvi.

Applications That Motivate Students

- Applications in the exposition, examples, and exercises use real life data for students to see the relevance of what they are learning.
- Interesting topics are included throughout the book to help students see the practical, as well as theoretical, side of mathematics.
- Sourced data sets are included throughout the text, allowing students the opportunity to generate mathematical models that represent real data.



Section 1.8 ▶ Applications and Models 203

24. ***Angle of Depression*** A Global Positioning System satellite orbits 12,500 miles above Earth's surface. Find the angle of depression from the satellite to the horizon. Assume the radius of Earth is 4000 miles.

25. ***Angle of Depression*** A cellular telephone tower that is 150 feet tall is placed on top of a mountain that is 1200 feet above sea level. What is the angle of depression from the top of the tower to a cell phone user who is 5 horizontal miles away and 400 feet above sea level?

26. ***Airplane Ascent*** During takeoff, an airplane's angle of climb is 18° and its speed is 275 feet per second.
   (a) Find the plane's altitude after 1 minute.
   (b) How long will it take the plane to climb to an altitude of 10,000 feet?

27. ***Mountain Descent*** A sign on a roadway at the top of a mountain indicates that for the next 4 miles the grade is 10.5° (see figure). Find the change in elevation for a car descending the mountain.

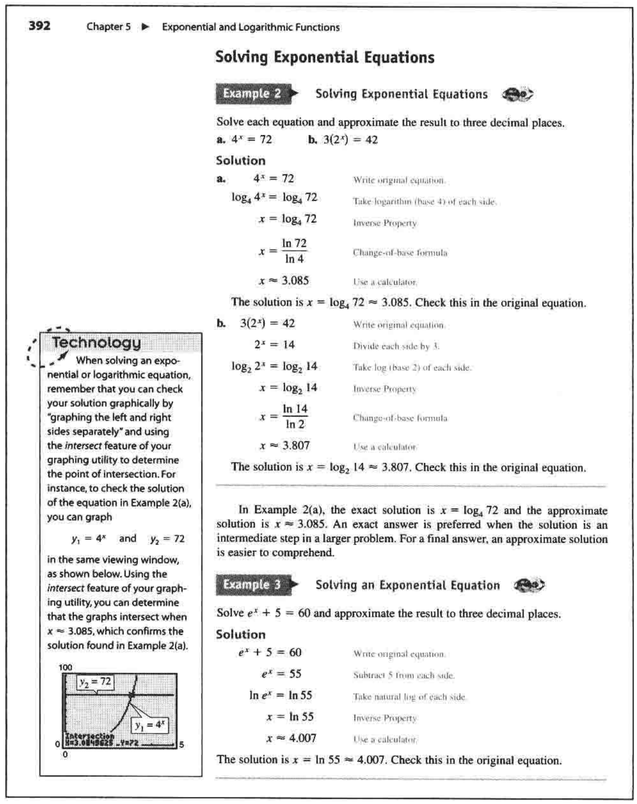
30. ***Surveying*** A surveyor wishes to find the distance across a swamp (see figure). The bearing from A to B is N 32° W. The surveyor walks 50 meters from A, and at the point C the bearing to B is N 68° W. Find (a) the bearing from A to C and (b) the distance from A to B.

31. ***Location of a Fire*** Two fire towers are 30 kilometers apart, where tower A is due west of tower B. A fire is spotted from the towers, and the bearings from A and B are E 14° N and W 34° N, respectively (see figure). Find the distance d of the fire from the line segment AB.

32. ***Navigation*** A ship is 45 miles east and 30 miles south of port. The captain wants to sail directly to

Readable and Understandable Text for Students

- Examples, explanations, and proofs begin and end on the same page to allow students to see concepts as a whole, without page-turning distractions. This unique design is one more example of the carefully developed texts created by the Larson Team.
- Examples include detailed solutions that show all steps to make it easy for students to understand the material being presented.
- Many examples include numerical, algebraic, and/or graphical presentations to provide students an opportunity to see the solution represented in a way that is most clear to them.



392 Chapter 5 ▶ Exponential and Logarithmic Functions

Solving Exponential Equations

Example 2 ▶ **Solving Exponential Equations**

Solve each equation and approximate the result to three decimal places.

a. $4^x = 72$ **b.** $3(2^x) = 42$

Solution

a.
$4^x = 72$ Write original equation.
$\log_4 4^x = \log_4 72$ Take logarithm (base 4) of each side.
$x = \log_4 72$ Inverse Property
$x = \frac{\ln 72}{\ln 4}$ Change-of-base formula
$x \approx 3.085$ Use a calculator.

The solution is $x = \log_4 72 \approx 3.085$. Check this in the original equation.

b.
$3(2^x) = 42$ Write original equation.
$2^x = 14$ Divide each side by 3.
$\log_2 2^x = \log_2 14$ Take log (base 2) of each side.
$x = \log_2 14$ Inverse Property
$x = \frac{\ln 14}{\ln 2}$ Change-of-base formula
$x \approx 3.807$ Use a calculator.

The solution is $x = \log_2 14 \approx 3.807$. Check this in the original equation.

In Example 2(a), the exact solution is $x = \log_4 72$ and the approximate solution is $x \approx 3.085$. An exact answer is preferred when the solution is an intermediate step in a larger problem. For a final answer, an approximate solution is easier to comprehend.

Example 3 ▶ **Solving an Exponential Equation**

Solve $e^x + 5 = 60$ and approximate the result to three decimal places.

Solution

$e^x + 5 = 60$ Write original equation.
$e^x = 55$ Subtract 5 from each side.
$\ln e^x = \ln 55$ Take natural log of each side.
$x = \ln 55$ Inverse Property
$x \approx 4.007$ Use a calculator.

The solution is $x = \ln 55 \approx 4.007$. Check this in the original equation.

Technology

When solving an exponential or logarithmic equation, remember that you can check your solution graphically by "graphing the left and right sides separately" and using the *intersect* feature of your graphing utility to determine the point of intersection. For instance, to check the solution of the equation in Example 2(a), you can graph

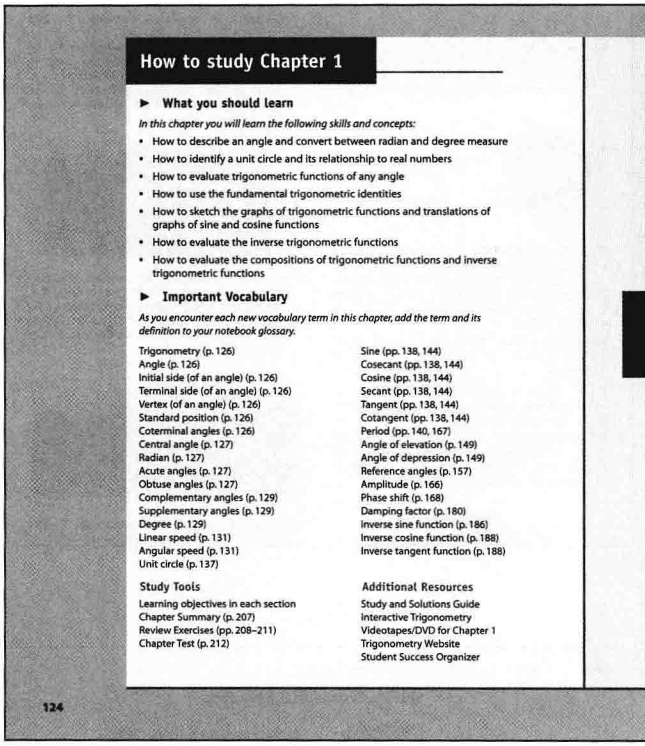
$y_1 = 4^x$ and $y_2 = 72$

in the same viewing window, as shown below. Using the *intersect* feature of your graphing utility, you can determine that the graphs intersect when $x \approx 3.085$, which confirms the solution found in Example 2(a).

FEATURES

Textbook Highlights

Student Success Tools



How to study Chapter 1

▶ **What you should learn**

In this chapter you will learn the following skills and concepts:

- How to describe an angle and convert between radian and degree measure
- How to identify a unit circle and its relationship to real numbers
- How to evaluate trigonometric functions of any angle
- How to use the fundamental trigonometric identities
- How to sketch the graphs of trigonometric functions and translations of graphs of sine and cosine functions
- How to evaluate the inverse trigonometric functions
- How to evaluate the compositions of trigonometric functions and inverse trigonometric functions

▶ **Important Vocabulary**

As you encounter each new vocabulary term in this chapter, add the term and its definition to your notebook glossary.

Trigonometry (p. 126)	Sine (pp. 138, 144)
Angle (p. 126)	Cosecant (pp. 138, 144)
Initial side (of an angle) (p. 126)	Cosine (pp. 138, 144)
Terminal side (of an angle) (p. 126)	Secant (pp. 138, 144)
Vertex (of an angle) (p. 126)	Tangent (pp. 138, 144)
Standard position (p. 126)	Cotangent (pp. 138, 144)
Coterminal angles (p. 126)	Period (pp. 140, 167)
Central angle (p. 127)	Angle of elevation (p. 149)
Radian (p. 127)	Angle of depression (p. 149)
Acute angles (p. 127)	Reference angles (p. 157)
Obtuse angles (p. 127)	Amplitude (p. 166)
Complementary angles (p. 129)	Phase shift (p. 168)
Supplementary angles (p. 129)	Damping factor (p. 180)
Degree (p. 129)	Inverse sine function (p. 186)
Linear speed (p. 131)	Inverse cosine function (p. 188)
Angular speed (p. 131)	Inverse tangent function (p. 188)
Unit circle (p. 137)	

Study Tools	Additional Resources
Learning objectives in each section	Study and Solutions Guide
Chapter Summary (p. 207)	Interactive Trigonometry
Review Exercises (pp. 208–211)	Videotapes/DVD for Chapter 1
Chapter Test (p. 212)	Trigonometry Website
	Student Success Organizer

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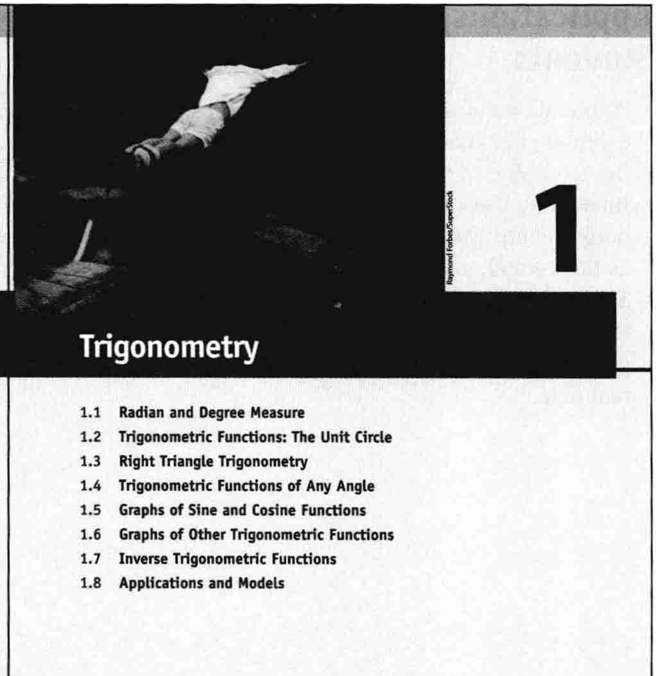
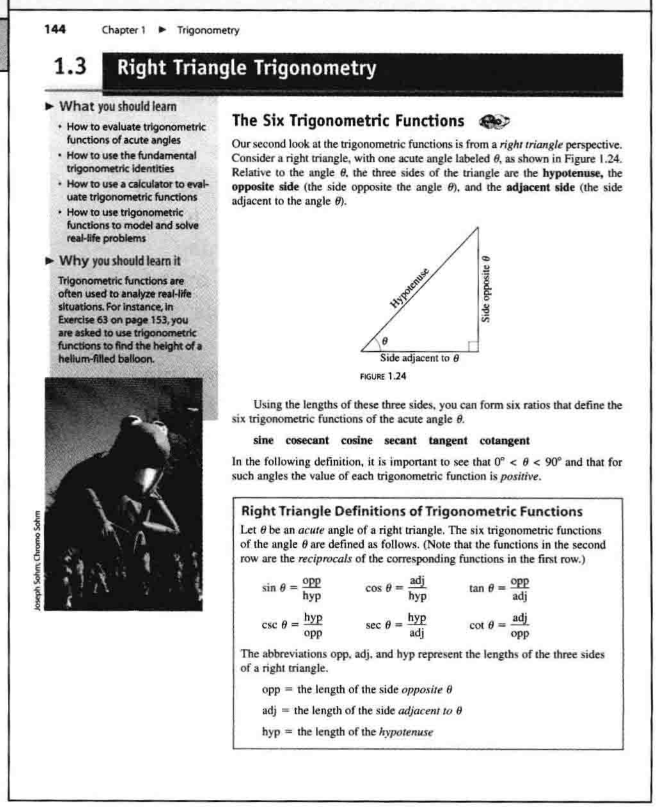


Raymond Forbes/SuperStock

1

Trigonometry

1.1 Radian and Degree Measure
1.2 Trigonometric Functions: The Unit Circle
1.3 Right Triangle Trigonometry
1.4 Trigonometric Functions of Any Angle
1.5 Graphs of Sine and Cosine Functions
1.6 Graphs of Other Trigonometric Functions
1.7 Inverse Trigonometric Functions
1.8 Applications and Models



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1.3 Right Triangle Trigonometry

▶ What you should learn

- How to evaluate trigonometric functions of acute angles
- How to use the fundamental trigonometric identities
- How to use a calculator to evaluate trigonometric functions
- How to use trigonometric functions to model and solve real-life problems

▶ Why you should learn it

Trigonometric functions are often used to analyze real-life situations. For instance, in Exercise 63 on page 153, you are asked to use trigonometric functions to find the height of a helium-filled balloon.

Joseph Sohm; Chromo Sohm

The Six Trigonometric Functions

Our second look at the trigonometric functions is from a *right triangle* perspective. Consider a right triangle, with one acute angle labeled θ, as shown in Figure 1.24. Relative to the angle θ, the three sides of the triangle are the **hypotenuse**, the **opposite side** (the side opposite the angle θ), and the **adjacent side** (the side adjacent to the angle θ).

FIGURE 1.24

Using the lengths of these three sides, you can form six ratios that define the six trigonometric functions of the acute angle θ.

sine cosecant cosine secant tangent cotangent

In the following definition, it is important to see that $0° < \theta < 90°$ and that for such angles the value of each trigonometric function is *positive*.

Right Triangle Definitions of Trigonometric Functions

Let θ be an *acute* angle of a right triangle. The six trigonometric functions of the angle θ are defined as follows. (Note that the functions in the second row are the *reciprocals* of the corresponding functions in the first row.)

$$\sin\theta = \frac{\text{opp}}{\text{hyp}} \qquad \cos\theta = \frac{\text{adj}}{\text{hyp}} \qquad \tan\theta = \frac{\text{opp}}{\text{adj}}$$

$$\csc\theta = \frac{\text{hyp}}{\text{opp}} \qquad \sec\theta = \frac{\text{hyp}}{\text{adj}} \qquad \cot\theta = \frac{\text{adj}}{\text{opp}}$$

The abbreviations opp, adj, and hyp represent the lengths of the three sides of a right triangle.

opp = the length of the side *opposite* θ

adj = the length of the side *adjacent to* θ

hyp = the length of the *hypotenuse*

"How to Study This Chapter"

The chapter-opening study guide includes: *What you should learn*, an objective-based overview of the main concepts of the chapter, *Important Vocabulary*, key mathematical terms integral to learning the concepts outlined in *What you should learn*, a list of *Study Tools*, additional study resources within the text chapter, and *Additional Resources*, text-specific supplemental resources available for each chapter.

Section Openers include: "What you should learn"

A list of section objectives outlining the main concepts to help students focus while reading through the section.

"Why you should learn it"

A real-life application or a reference to other branches of mathematics illustrates the relevance of the section's content. The real-life application is showcased in *Model It* found in the section exercise set.

Section 1.3 ▶ Right Triangle Trigonometry **153**

▶ Model It

63. ***Height*** A 20-meter line is used to tether a helium-filled balloon. Because of a breeze, the line makes an angle of approximately 85° with the ground.

(a) Draw a right triangle that gives a visual representation of the problem. Show the known quantities of the triangle and use a variable to indicate the height of the balloon.

(b) Use a trigonometric function to write an equation involving the unknown quantity.

(c) What is the height of the balloon?

(d) The breeze becomes stronger and the angle the balloon makes with the ground decreases. How does this affect the triangle you drew in part (a)?

(e) Complete the table, which shows the height (in meters) of the balloon for decreasing angle measures θ.

Angle, θ	80°	70°	60°	50°
Height				

Angle, θ	40°	30°	20°	10°
Height				

(f) As the angle the balloon makes with the ground approaches 0°, how does this affect the height of the balloon? Draw a right triangle to explain your reasoning.

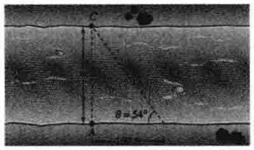
64. ***Angle of Elevation*** A ramp 20 feet in length rises to a loading platform that is $3\frac{1}{3}$ feet off the ground.

(a) Draw a right triangle that gives a visual representation of the problem. Show the known quantities of the triangle and use a variable to indicate the angle of elevation of the ramp.

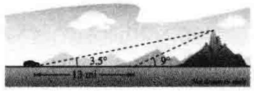
(b) Use a trigonometric function to write an equation involving the unknown quantity.

(c) What is the angle of elevation of the ramp?

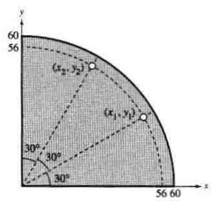
65. ***Width of a River*** A biologist wants to know the width w of a river in order to set instruments for studying the pollutants in the water. From point A, the biologist walks downstream 100 feet and sights to point C (see figure). From this sighting, it is determined that $\theta = 54°$. How wide is the river?



66. ***Height of a Mountain*** In traveling across flat land, you notice a mountain directly in front of you. Its angle of elevation (to the peak) is 3.5°. After you drive 13 miles closer to the mountain, the angle of elevation is 9°. Approximate the height of the mountain.



67. ***Machine Shop Calculations*** A steel plate has the form of one-fourth of a circle with a radius of 60 centimeters. Two two-centimeter holes are to be drilled in the plate positioned as shown in the figure. Find the coordinates of the center of each hole.



▶ Chapter Summary **207**

Chapter Summary

▶ *What* did you learn?

Section 1.1	Review Exercises
☐ How to describe angles	1–4
☐ How to use radian and degree measure	5–20
☐ How to use angles to model and solve real-life problems	21, 22
Section 1.2	
☐ How to identify a unit circle and its relationship to real numbers	23–26
☐ How to evaluate trigonometric functions using the unit circle	27–30
☐ How to use the domain and period to evaluate sine and cosine functions	31–34
☐ How to use a calculator to evaluate trigonometric functions	35–38
Section 1.3	
☐ How to evaluate trigonometric functions of acute angles	39–42
☐ How to use the fundamental trigonometric identities	43–46
☐ How to use a calculator to evaluate trigonometric functions	47–52
☐ How to use trigonometric functions to model and solve real-life problems	53, 54
Section 1.4	
☐ How to evaluate trigonometric functions of any angle	55–68
☐ How to use reference angles to evaluate trigonometric functions	69–76
☐ How to evaluate trigonometric functions of real numbers	77–82
Section 1.5	
☐ How to use amplitude and period to sketch the graphs of sine and cosine functions	83–86
☐ How to sketch translations of graphs of sine and cosine functions	87–90
☐ How to use sine and cosine functions to model real-life data	91, 92
Section 1.6	
☐ How to sketch the graphs of tangent and cotangent functions	93–96
☐ How to sketch the graphs of secant and cosecant functions	97–100
☐ How to sketch the graphs of damped trigonometric functions	101, 102
Section 1.7	
☐ How to evaluate the inverse sine function	103–108
☐ How to evaluate the other inverse trigonometric functions	109–120
☐ How to evaluate the compositions of trigonometric functions	121–128
Section 1.8	
☐ How to solve real-life problems involving right triangles	129, 130
☐ How to solve real-life problems involving directional bearings	131
☐ How to solve real-life problems involving harmonic motion	132

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Review Exercises

1.1 In Exercises 1–4, estimate the angle to the nearest one-half radian.

1. 
2. 
3. 
4. 

In Exercises 5–12, sketch the angle in standard position. List one positive and one negative coterminal angle.

5. $\frac{11\pi}{4}$ **6.** $\frac{2\pi}{9}$

7. $-\frac{4\pi}{3}$ **8.** $-\frac{23\pi}{3}$

9. 70° **10.** 280°

11. −110° **12.** −405°

In Exercises 13–16, convert the measure from radians to degrees. Round your answer to two decimal places.

13. $\frac{5\pi}{7}$ **14.** $-\frac{11\pi}{6}$

15. −3.5 **16.** 5.7

In Exercises 17–20, convert the measure from degrees to radians. Round your answer to four decimal places.

17. 480° **18.** −127.5°

19. −33° 45′ **20.** 196° 77′

21. ***Phonograph*** Compact discs have all but replaced phonograph records. Phonograph records are vinyl discs that rotate on a turntable. A typical record album is 12 inches in diameter and plays at $33\frac{1}{3}$ revolutions per minute.

(a) What is the angular speed of a record album?

(b) What is the linear speed of the outer edge of a record album?

22. ***Bicycle*** At what speed is a bicyclist traveling when his 27-inch-diameter tires are rotating at an angular speed of 5π radians per second?

1.2 In Exercises 23–26, find the point (x, y) on the unit circle that corresponds to the real number t.

23. $t = \frac{2\pi}{3}$ **24.** $t = \frac{3\pi}{4}$

25. $t = \frac{5\pi}{6}$ **26.** $t = -\frac{4\pi}{3}$

In Exercises 27–30, evaluate (if possible) the six trigonometric functions of the real number.

27. $t = \frac{7\pi}{6}$ **28.** $t = \frac{\pi}{4}$

29. $t = -\frac{2\pi}{3}$ **30.** $t = 2\pi$

In Exercises 31–34, evaluate the trigonometric function using its period as an aid.

31. $\sin \frac{11\pi}{4}$ **32.** $\cos 4\pi$

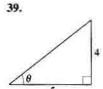
33. $\sin\left(-\frac{17\pi}{6}\right)$ **34.** $\cos\left(-\frac{13\pi}{3}\right)$

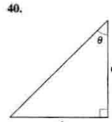
In Exercises 35–38, use a calculator to evaluate the trigonometric function. Round your answer to two decimal places.

35. tan 33 **36.** csc 10.5

37. $\sec \frac{12\pi}{5}$ **38.** $\sin\left(-\frac{\pi}{9}\right)$

1.3 In Exercises 39–42, find the exact values of the six trigonometric functions of the angle θ shown in the figure.

39. 

40. 

NEW! Model It

Often involving real-life data, these multi-part applications, referenced in *Why you should learn it*, offer students the opportunity to generate and analyze mathematical models.

"What did you learn?" Chapter Summary

The chapter summary provides a concise, section-by-section review of the section objectives. These objectives are correlated to the chapter Review Exercises allowing students to identify sections and concepts needing further review and study.

Review Exercises

Following the chapter summary, the Review Exercises provide additional practice and review of chapter concepts. The Review Exercises are organized by section and keyed directly to the section objectives listed in the chapter summary.

Additional **Student Success Tools** include point-of-use *Study Tips* and *Chapter* and *Cumulative Tests*.

FEATURES

Translations of Sine and Cosine Curves

The constant c in the general equations

$$y = a\sin(bx - c) \quad \text{and} \quad y = a\cos(bx - c)$$

creates a *horizontal translation* (shift) of the basic sine and cosine curves. Comparing $y = a\sin bx$ with $y = a\sin(bx - c)$, you find that the graph of $y = a\sin(bx - c)$ completes one cycle from $bx - c = 0$ to $bx - c = 2\pi$. By solving for x, you can find the interval for one cycle to be

$$\underbrace{\frac{c}{b}}_{\text{Left endpoint}} \le x \le \underbrace{\frac{c}{b} + \frac{2\pi}{b}}_{\text{Right endpoint}}.$$

Period: $\frac{2\pi}{b}$

This implies that the period of $y = a\sin(bx - c)$ is $2\pi/b$, and the graph of $y = a\sin bx$ is shifted by an amount c/b. The number c/b is the **phase shift.**

Exploration

Sketch the graph of

$y = \sin(x - c)$

where $c = -\pi/4$, 0, and $\pi/4$. How does the value of c affect the graph?

Graphs of Sine and Cosine Functions

The graphs of $y = a\sin(bx - c)$ and $y = a\cos(bx - c)$ have the following characteristics. (Assume $b > 0$.)

Amplitude $= |a|$ Period $= \frac{2\pi}{b}$

The left and right endpoints of a one-cycle interval can be determined by solving the equations $bx - c = 0$ and $bx - c = 2\pi$.

Example 4 ▶ **Horizontal Translation**

Sketch the graph of $y = \frac{1}{2}\sin(x - \pi/3)$.

Solution

The amplitude is $\frac{1}{2}$ and the period is 2π. By solving the equations

$$x - \frac{\pi}{3} = 0 \implies x = \frac{\pi}{3}$$

and

$$x - \frac{\pi}{3} = 2\pi \implies x = \frac{7\pi}{3}$$

you see that the interval $[\pi/3, 7\pi/3]$ corresponds to one cycle of the graph. Dividing this interval into four equal parts produces the key points

Intercept	*Maximum*	*Intercept*	*Minimum*		*Intercept*
$\left(\frac{\pi}{3}, 0\right)$,	$\left(\frac{5\pi}{6}, \frac{1}{2}\right)$,	$\left(\frac{4\pi}{3}, 0\right)$,	$\left(\frac{11\pi}{6}, -\frac{1}{2}\right)$,	and	$\left(\frac{7\pi}{3}, 0\right)$.

The graph is shown in Figure 1.52.

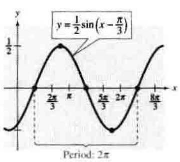


FIGURE 1.52

Exploration

Before introducing selected topics, *Explorations* engage students in active discovery of mathematical concepts and relationships, often through the power of technology, while strengthening their critical thinking skills and developing an intuitive understanding of theoretical concepts.

Examples

Each example was carefully chosen to illustrate a particular mathematical concept or problem solving skill. Every example contains step-by-step solutions, most with side-by-side explanations that lead students through the solution process.

Technology

Point-of-use instructions for graphing utilities appear in the margin. Emphasis is placed on using technology as a tool for visualizing mathematical concepts, for verifying solutions, and for facilitating mathematical computation. The use of technology is optional and this feature and related exercises, identified by the icon, can be omitted without loss of continuity in coverage of topics.

Solving Exponential Equations

Example 2 ▶ **Solving Exponential Equations**

Solve each equation and approximate the result to three decimal places.

a. $4^x = 72$ **b.** $3(2^x) = 42$

Solution

a.

$4^x = 72$	Write original equation.
$\log_4 4^x = \log_4 72$	Take logarithm (base 4) of each side.
$x = \log_4 72$	Inverse Property
$x = \frac{\ln 72}{\ln 4}$	Change-of-base formula
$x \approx 3.085$	Use a calculator.

The solution is $x = \log_4 72 \approx 3.085$. Check this in the original equation.

b.

$3(2^x) = 42$	Write original equation.
$2^x = 14$	Divide each side by 3.
$\log_2 2^x = \log_2 14$	Take log (base 2) of each side.
$x = \log_2 14$	Inverse Property
$x = \frac{\ln 14}{\ln 2}$	Change-of-base formula
$x \approx 3.807$	Use a calculator.

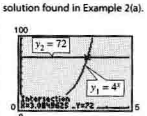
The solution is $x = \log_2 14 \approx 3.807$. Check this in the original equation.

Technology

When solving an exponential or logarithmic equation, remember that you can check your solution graphically by "graphing the left and right sides separately" and using the *intersect* feature of your graphing utility to determine the point of intersection. For instance, to check the solution of the equation in Example 2(a), you can graph

$y_1 = 4^x$ and $y_2 = 72$

in the same viewing window, as shown below. Using the *intersect* feature of your graphing utility, you can determine that the graphs intersect when $x \approx 3.085$, which confirms the solution found in Example 2(a).



In Example 2(a), the exact solution is $x = \log_4 72$ and the approximate solution is $x \approx 3.085$. An exact answer is preferred when the solution is an intermediate step in a larger problem. For a final answer, an approximate solution is easier to comprehend.

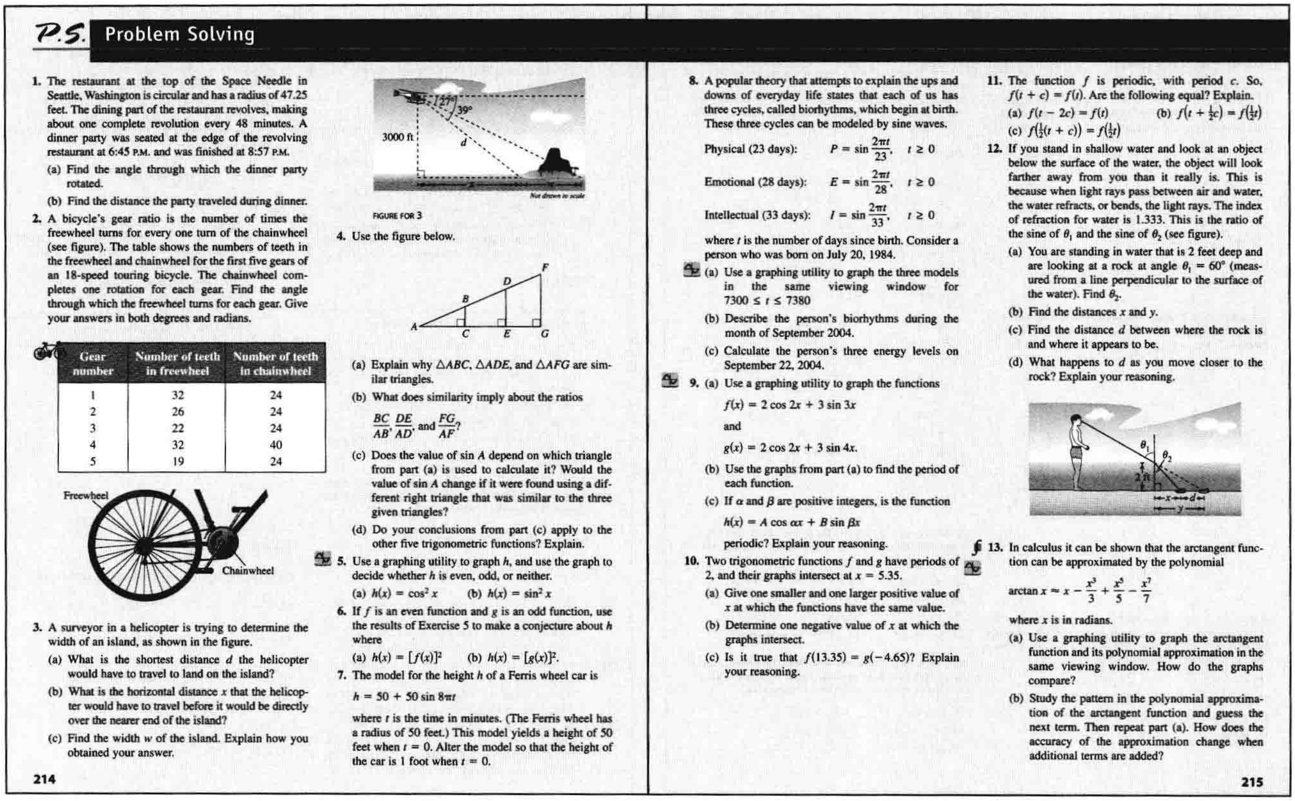
Example 3 ▶ **Solving an Exponential Equation**

Solve $e^x + 5 = 60$ and approximate the result to three decimal places.

Solution

$e^x + 5 = 60$	Write original equation.
$e^x = 55$	Subtract 5 from each side.
$\ln e^x = \ln 55$	Take natural log of each side.
$x = \ln 55$	Inverse Property
$x \approx 4.007$	Use a calculator.

The solution is $x = \ln 55 \approx 4.007$. Check this in the original equation.



P.S. **Problem Solving**

1. The restaurant at the top of the Space Needle in Seattle, Washington is circular and has a radius of 47.25 feet. The dining part of the restaurant revolves, making about one complete revolution every 48 minutes. A dinner party was seated at the edge of the revolving restaurant at 6:45 P.M. and was finished at 8:57 P.M.
   (a) Find the angle through which the dinner party rotated.
   (b) Find the distance the party traveled during dinner.
2. A bicycle's gear ratio is the number of times the freewheel turns for every one turn of the chainwheel (see figure). The table shows the numbers of teeth in the freewheel and chainwheel for the first five gears of an 18-speed touring bicycle. The chainwheel completes one rotation for each gear. Find the angle through which the freewheel turns for each gear. Give your answers in both degrees and radians.

Gear number	Number of teeth in freewheel	Number of teeth in chainwheel
1	32	24
2	26	24
3	22	24
4	32	40
5	19	24

Freewheel
Chainwheel

3. A surveyor in a helicopter is trying to determine the width of an island, as shown in the figure.
   (a) What is the shortest distance d the helicopter would have to travel to land on the island?
   (b) What is the horizontal distance x that the helicopter would have to travel before it would be directly over the nearer end of the island?
   (c) Find the width w of the island. Explain how you obtained your answer.

3000 ft, 27°, 39°, d, Not drawn to scale

FIGURE FOR 3

4. Use the figure below.
   (a) Explain why $\triangle ABC$, $\triangle ADE$, and $\triangle AFG$ are similar triangles.
   (b) What does similarity imply about the ratios $\frac{BC}{AB}, \frac{DE}{AD}$, and $\frac{FG}{AF}$?
   (c) Does the value of sin A depend on which triangle from part (a) is used to calculate it? Would the value of sin A change if it were found using a different right triangle that was similar to the three given triangles?
   (d) Do your conclusions from part (c) apply to the other five trigonometric functions? Explain.
5. Use a graphing utility to graph h, and use the graph to decide whether h is even, odd, or neither.
   (a) $h(x) = \cos^2 x$ (b) $h(x) = \sin^2 x$
6. If f is an even function and g is an odd function, use the results of Exercise 5 to make a conjecture about h where
   (a) $h(x) = [f(x)]^2$ (b) $h(x) = [g(x)]^2$.
7. The model for the height h of a Ferris wheel car is
   $h = 50 + 50 \sin 8\pi t$
   where t is the time in minutes. (The Ferris wheel has a radius of 50 feet.) This model yields a height of 50 feet when $t = 0$. Alter the model so that the height of the car is 1 foot when $t = 0$.

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8. A popular theory that attempts to explain the ups and downs of everyday life states that each of us has three cycles, called biorhythms, which begin at birth. These three cycles can be modeled by sine waves.
   Physical (23 days): $P = \sin \frac{2\pi t}{23}, \quad t \geq 0$
   Emotional (28 days): $E = \sin \frac{2\pi t}{28}, \quad t \geq 0$
   Intellectual (33 days): $I = \sin \frac{2\pi t}{33}, \quad t \geq 0$
   where t is the number of days since birth. Consider a person who was born on July 20, 1984.
   (a) Use a graphing utility to graph the three models in the same viewing window for $7300 \leq t \leq 7380$.
   (b) Describe the person's biorhythms during the month of September 2004.
   (c) Calculate the person's three energy levels on September 22, 2004.
9. (a) Use a graphing utility to graph the functions
   $f(x) = 2 \cos 2x + 3 \sin 3x$
   and
   $g(x) = 2 \cos 2x + 3 \sin 4x$.
   (b) Use the graphs from part (a) to find the period of each function.
   (c) If α and β are positive integers, is the function
   $h(x) = A \cos \alpha x + B \sin \beta x$
   periodic? Explain your reasoning.
10. Two trigonometric functions f and g have periods of 2, and their graphs intersect at $x = 5.35$.
   (a) Give one smaller and one larger positive value of x at which the functions have the same value.
   (b) Determine one negative value of x at which the graphs intersect.
   (c) Is it true that $f(13.35) = g(-4.65)$? Explain your reasoning.
11. The function f is periodic, with period c. So, $f(t + c) = f(t)$. Are the following equal? Explain.
   (a) $f(t - 2c) = f(t)$ (b) $f(t + \frac{1}{2}c) = f(\frac{1}{2}t)$
   (c) $f(\frac{1}{2}(t + c)) = f(\frac{1}{2}t)$
12. If you stand in shallow water and look at an object below the surface of the water, the object will look farther away from you than it really is. This is because when light rays pass between air and water, the water refracts, or bends, the light rays. The index of refraction for water is 1.333. This is the ratio of the sine of θ_1 and the sine of θ_2 (see figure).
   (a) You are standing in water that is 2 feet deep and are looking at a rock at angle $\theta_1 = 60°$ (measured from a line perpendicular to the surface of the water). Find θ_2.
   (b) Find the distances x and y.
   (c) Find the distance d between where the rock is and where it appears to be.
   (d) What happens to d as you move closer to the rock? Explain your reasoning.
13. In calculus it can be shown that the arctangent function can be approximated by the polynomial
   $\arctan x \approx x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7}$
   where x is in radians.
   (a) Use a graphing utility to graph the arctangent function and its polynomial approximation in the same viewing window. How do the graphs compare?
   (b) Study the pattern in the polynomial approximation of the arctangent function and guess the next term. Then repeat part (a). How does the accuracy of the approximation change when additional terms are added?

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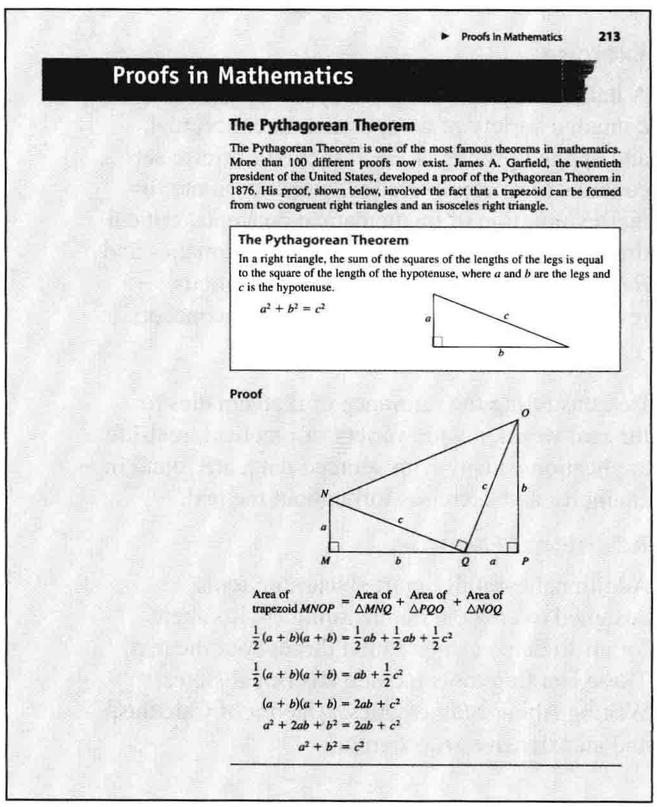
NEW! P.S. Problem Solving

Each chapter concludes with a collection of thought-provoking and challenging exercises that further explore and expand upon the chapter concepts. These exercises have unusual characteristics that set them apart from traditional text exercises.

NEW! Proofs in Mathematics

At the end of every chapter, Proofs in Mathematics emphasizes the importance of proofs in mathematics. Proofs of important mathematical properties and theorems are presented as well as discussions of various proof techniques.



▶ Proofs in Mathematics 213

Proofs in Mathematics

The Pythagorean Theorem

The Pythagorean Theorem is one of the most famous theorems in mathematics. More than 100 different proofs now exist. James A. Garfield, the twentieth president of the United States, developed a proof of the Pythagorean Theorem in 1876. His proof, shown below, involved the fact that a trapezoid can be formed from two congruent right triangles and an isosceles right triangle.

The Pythagorean Theorem
In a right triangle, the sum of the squares of the lengths of the legs is equal to the square of the length of the hypotenuse, where a and b are the legs and c is the hypotenuse.
$a^2 + b^2 = c^2$

Proof

Area of trapezoid $MNOP$ = Area of $\triangle MNQ$ + Area of $\triangle PQO$ + Area of $\triangle NOQ$

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

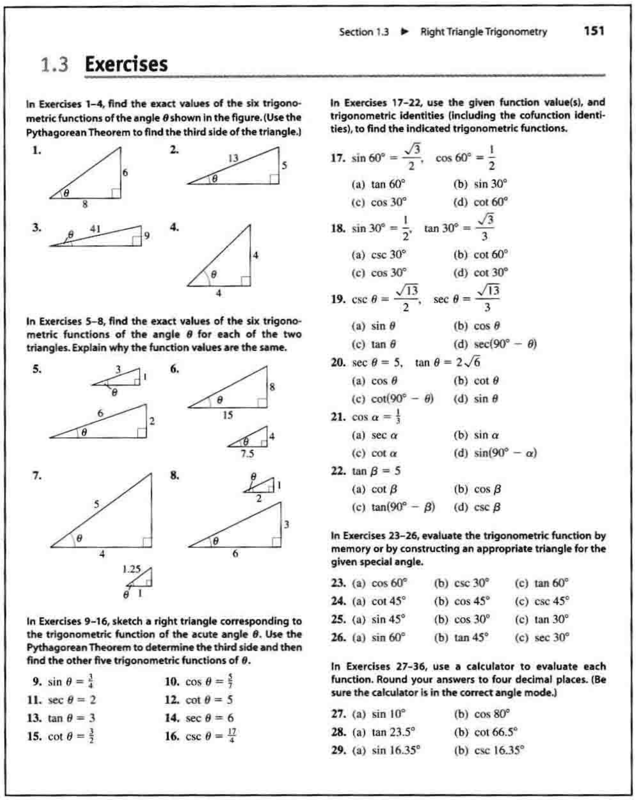
$\frac{1}{2}(a + b)(a + b) = ab + \frac{1}{2}c^2$

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

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

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

FEATURES


Section 1.3 ▶ Right Triangle Trigonometry 151

1.3 Exercises

In Exercises 1–4, find the exact values of the six trigonometric functions of the angle θ shown in the figure. (Use the Pythagorean Theorem to find the third side of the triangle.)

1. 2. 3. 4.

In Exercises 5–8, find the exact values of the six trigonometric functions of the angle θ for each of the two triangles. Explain why the function values are the same.

5. 6. 7. 8.

In Exercises 9–16, sketch a right triangle corresponding to the trigonometric function of the acute angle θ. Use the Pythagorean Theorem to determine the third side and then find the other five trigonometric functions of θ.

9. $\sin\theta = \frac{3}{4}$ 10. $\cos\theta = \frac{5}{7}$
11. $\sec\theta = 2$ 12. $\cot\theta = 5$
13. $\tan\theta = 3$ 14. $\sec\theta = 6$
15. $\cot\theta = \frac{3}{2}$ 16. $\csc\theta = \frac{17}{4}$

In Exercises 17–22, use the given function value(s), and trigonometric identities (including the cofunction identities), to find the indicated trigonometric functions.

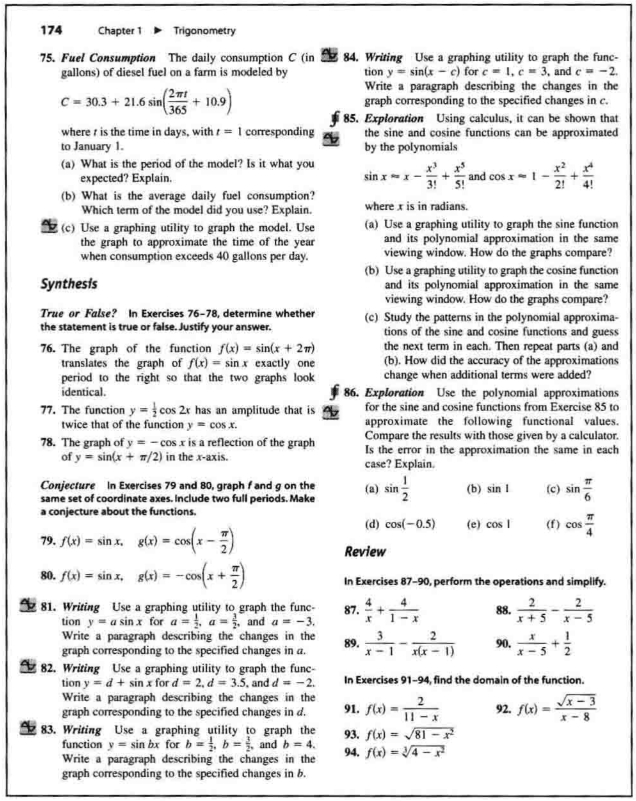
17. $\sin 60° = \frac{\sqrt{3}}{2}$, $\cos 60° = \frac{1}{2}$
(a) $\tan 60°$ (b) $\sin 30°$ (c) $\cos 30°$ (d) $\cot 60°$
18. $\sin 30° = \frac{1}{2}$, $\tan 30° = \frac{\sqrt{3}}{3}$
(a) $\csc 30°$ (b) $\cot 60°$ (c) $\cos 30°$ (d) $\cot 30°$
19. $\csc\theta = \frac{\sqrt{13}}{2}$, $\sec\theta = \frac{\sqrt{13}}{3}$
(a) $\sin\theta$ (b) $\cos\theta$ (c) $\tan\theta$ (d) $\sec(90° - \theta)$
20. $\sec\theta = 5$, $\tan\theta = 2\sqrt{6}$
(a) $\cos\theta$ (b) $\cot\theta$ (c) $\cot(90° - \theta)$ (d) $\sin\theta$
21. $\cos\alpha = \frac{1}{3}$
(a) $\sec\alpha$ (b) $\sin\alpha$ (c) $\cot\alpha$ (d) $\sin(90° - \alpha)$
22. $\tan\beta = 5$
(a) $\cot\beta$ (b) $\cos\beta$ (c) $\tan(90° - \beta)$ (d) $\csc\beta$

In Exercises 23–26, evaluate the trigonometric function by memory or by constructing an appropriate triangle for the given special angle.

23. (a) $\cos 60°$ (b) $\csc 30°$ (c) $\tan 60°$
24. (a) $\cot 45°$ (b) $\cos 45°$ (c) $\csc 45°$
25. (a) $\sin 45°$ (b) $\cos 30°$ (c) $\tan 30°$
26. (a) $\sin 60°$ (b) $\tan 45°$ (c) $\sec 30°$

In Exercises 27–36, use a calculator to evaluate each function. Round your answers to four decimal places. (Be sure the calculator is in the correct angle mode.)

27. (a) $\sin 10°$ (b) $\cos 80°$
28. (a) $\tan 23.5°$ (b) $\cot 66.5°$
29. (a) $\sin 16.35°$ (b) $\csc 16.35°$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75. *Fuel Consumption* The daily consumption C (in gallons) of diesel fuel on a farm is modeled by

$$C = 30.3 + 21.6\sin\left(\frac{2\pi t}{365} + 10.9\right)$$

where t is the time in days, with $t = 1$ corresponding to January 1.
(a) What is the period of the model? Is it what you expected? Explain.
(b) What is the average daily fuel consumption? Which term of the model did you use? Explain.
(c) Use a graphing utility to graph the model. Use the graph to approximate the time of the year when consumption exceeds 40 gallons per day.

Synthesis

True or False? In Exercises 76–78, determine whether the statement is true or false. Justify your answer.

76. The graph of the function $f(x) = \sin(x + 2\pi)$ translates the graph of $f(x) = \sin x$ exactly one period to the right so that the two graphs look identical.
77. The function $y = \frac{1}{2}\cos 2x$ has an amplitude that is twice that of the function $y = \cos x$.
78. The graph of $y = -\cos x$ is a reflection of the graph of $y = \sin(x + \pi/2)$ in the x-axis.

Conjecture In Exercises 79 and 80, graph f and g on the same set of coordinate axes. Include two full periods. Make a conjecture about the functions.

79. $f(x) = \sin x$, $g(x) = \cos\left(x - \frac{\pi}{2}\right)$
80. $f(x) = \sin x$, $g(x) = -\cos\left(x + \frac{\pi}{2}\right)$

81. *Writing* Use a graphing utility to graph the function $y = a\sin x$ for $a = \frac{1}{2}$, $a = \frac{3}{2}$, and $a = -3$. Write a paragraph describing the changes in the graph corresponding to the specified changes in a.
82. *Writing* Use a graphing utility to graph the function $y = d + \sin x$ for $d = 2$, $d = 3.5$, and $d = -2$. Write a paragraph describing the changes in the graph corresponding to the specified changes in d.
83. *Writing* Use a graphing utility to graph the function $y = \sin bx$ for $b = \frac{1}{2}$, $b = \frac{3}{2}$, and $b = 4$. Write a paragraph describing the changes in the graph corresponding to the specified changes in b.
84. *Writing* Use a graphing utility to graph the function $y = \sin(x - c)$ for $c = 1$, $c = 3$, and $c = -2$. Write a paragraph describing the changes in the graph corresponding to the specified changes in c.
85. *Exploration* Using calculus, it can be shown that the sine and cosine functions can be approximated by the polynomials

$$\sin x \approx x - \frac{x^3}{3!} + \frac{x^5}{5!} \text{ and } \cos x \approx 1 - \frac{x^2}{2!} + \frac{x^4}{4!}$$

where x is in radians.
(a) Use a graphing utility to graph the sine function and its polynomial approximation in the same viewing window. How do the graphs compare?
(b) Use a graphing utility to graph the cosine function and its polynomial approximation in the same viewing window. How do the graphs compare?
(c) Study the patterns in the polynomial approximations of the sine and cosine functions and guess the next term in each. Then repeat parts (a) and (b). How did the accuracy of the approximations change when additional terms were added?
86. *Exploration* Use the polynomial approximations for the sine and cosine functions from Exercise 85 to approximate the following functional values. Compare the results with those given by a calculator. Is the error in the approximation the same in each case? Explain.
(a) $\sin\frac{1}{2}$ (b) $\sin 1$ (c) $\sin\frac{\pi}{6}$
(d) $\cos(-0.5)$ (e) $\cos 1$ (f) $\cos\frac{\pi}{4}$

Review

In Exercises 87–90, perform the operations and simplify.

87. $\frac{4}{x} + \frac{4}{1-x}$ 88. $\frac{2}{x+5} - \frac{2}{x-5}$
89. $\frac{3}{x-1} - \frac{2}{x(x-1)}$ 90. $\frac{x}{x-5} + \frac{1}{2}$

In Exercises 91–94, find the domain of the function.

91. $f(x) = \frac{2}{11-x}$ 92. $f(x) = \frac{\sqrt{x-3}}{x-8}$
93. $f(x) = \sqrt{81 - x^2}$
94. $f(x) = \sqrt[3]{4 - x^2}$

Exercises

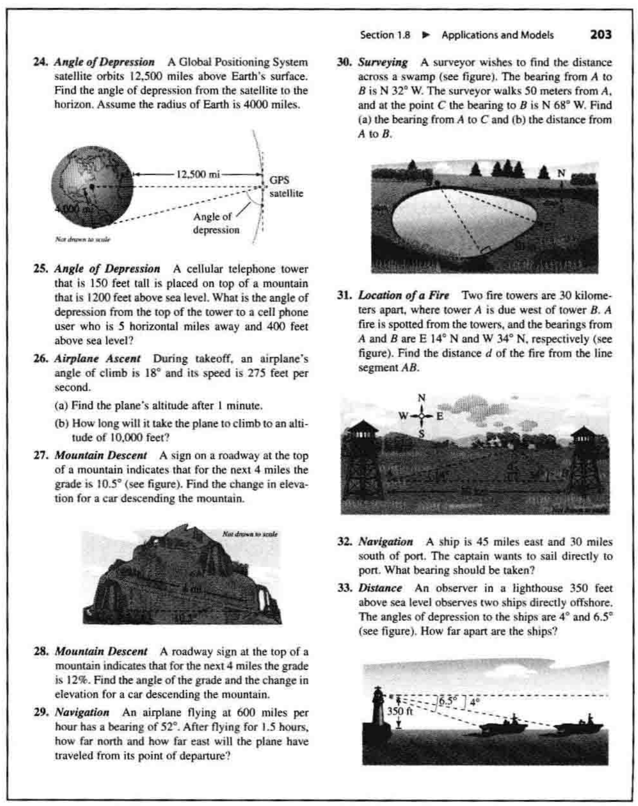
A hallmark feature of the text, the exercise sets contain a variety of computational, conceptual, and applied problems. Each section exercise set contains *Synthesis* exercises, which promote further exploration of mathematical concepts, critical thinking skills, and writing about mathematics and *Review* exercises, which provide continuous review of previously learned skills and concepts.

Applications

Demonstrating the relevance of mathematics to the real world, a wide variety of practical, real-life applications, many with sourced data, are found in examples and exercises throughout the text.

Additional Features

Additional carefully crafted learning tools designed to create a rich learning environment for all students can be found throughout the text. These learning tools include Historical Notes, Writing About Mathematics, Algebra of Calculus, and an extensive art program.


Section 1.8 ▶ Applications and Models 203

24. *Angle of Depression* A Global Positioning System satellite orbits 12,500 miles above Earth's surface. Find the angle of depression from the satellite to the horizon. Assume the radius of Earth is 4000 miles.
25. *Angle of Depression* A cellular telephone tower that is 150 feet tall is placed on top of a mountain that is 1200 feet above sea level. What is the angle of depression from the top of the tower to a cell phone user who is 5 horizontal miles away and 400 feet above sea level?
26. *Airplane Ascent* During takeoff, an airplane's angle of climb is 18° and its speed is 275 feet per second.
(a) Find the plane's altitude after 1 minute.
(b) How long will it take the plane to climb to an altitude of 10,000 feet?
27. *Mountain Descent* A sign on a roadway at the top of a mountain indicates that for the next 4 miles the grade is 10.5° (see figure). Find the change in elevation for a car descending the mountain.
28. *Mountain Descent* A roadway sign at the top of a mountain indicates that for the next 4 miles the grade is 12%. Find the angle of the grade and the change in elevation for a car descending the mountain.
29. *Navigation* An airplane flying at 600 miles per hour has a bearing of 52°. After flying for 1.5 hours, how far north and how far east will the plane have traveled from its point of departure?
30. *Surveying* A surveyor wishes to find the distance across a swamp (see figure). The bearing from A to B is N 32° W. The surveyor walks 50 meters from A, and at the point C the bearing to B is N 68° W. Find (a) the bearing from A to C and (b) the distance from A to B.
31. *Location of a Fire* Two fire towers are 30 kilometers apart, where tower A is due west of tower B. A fire is spotted from the towers, and the bearings from A and B are E 14° N and W 34° N, respectively (see figure). Find the distance d of the fire from the line segment AB.
32. *Navigation* A ship is 45 miles east and 30 miles south of port. The captain wants to sail directly to port. What bearing should be taken?
33. *Distance* An observer in a lighthouse 350 feet above sea level observes two ships directly offshore. The angles of depression to the ships are 4° and 6.5° (see figure). How far apart are the ships?

Program Components

Trigonometry, Student Edition
Trigonometry, Instructor's Annotated Edition

Interactive Trigonometry 3.0 CD-ROM (can be used alone or with the printed textbook)
Internet Trigonometry 3.0 (can be used alone or with the printed textbook)

Additional Resources

Student Resources

Student Success Organizer

Study and Solutions Guide
by Dianna L. Zook, (Indiana University/Purdue University–Fort Wayne)

Student Technology Resources

Instructional Videotapes for Graphing Calculators
by Dana Mosley

Learning Tools Student CD-ROM

Smarthinking™.com live online tutoring

Instructional DVDs by Dana Mosley

Instructional Videotapes for Graphing Calculators
by Dana Mosley

Interactive Trigonometry 3.0 CD-ROM

Internet Trigonometry 3.0

HM eduSpace website

BlackBoard Course Cartridge

WebCT e-pack

Textbook website (math.college.hmco.com)

Instructor Resources

Instructor Success Organizer

Complete Solutions Guide
by Dianna L. Zook, (Indiana University/Purdue University–Fort Wayne)

Instructor's Annotated Edition

Test Item File

Instructor Technology Resources

HMClassPrep™ Instructor's CD-ROM

HM Testing 6.03

PowerPoint Presentations

Instructional Videotapes by Dana Mosley
(ideal for libraries and resource centers)

Interactive Trigonometry 3.0 CD-ROM

Internet Trigonometry 3.0

HM eduSpace website

BlackBoard Course Cartridge

WebCT e-pack

Textbook website (math.college.hmco.com)

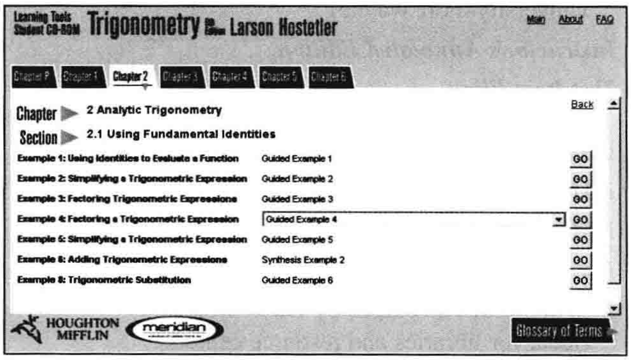
For more information on these and other resources available, visit our website at **math.college.hmco.com.**

Trigonometry, Sixth Edition
Learning Tools Student CD-ROM

The Learning Tools Student CD-ROM that accompanies the text provides students with an unprecedented quantity of support materials and resources that help bring mathematics to life with motion and sound. These electronic learning tools are separated into three components described below. The CD-ROM also provides access to MathGraphs, ACE Practice Tests, and SMARTHINKING, the online tutoring center.

Study the Lesson

The Glossary of Terms provides a comprehensive list of important mathematical terms for each chapter with a short definition of each term.

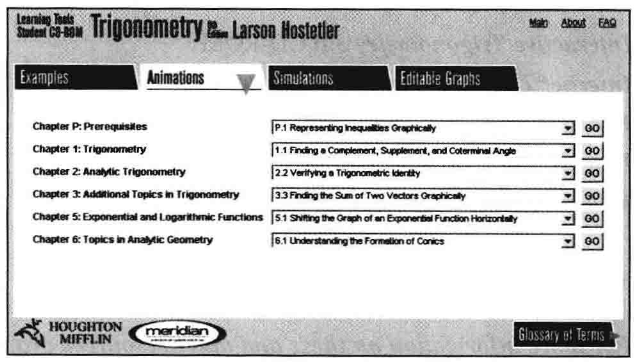


Review and Practice

- **Guided Examples** provide a full range of support by walking students step-by-step through problems that relate to a specific concept in the text.
- **Synthesis Examples** require the use of more than one concept from a section and encourage students to work through a solution of a problem one step at a time.

Visualize and Extend the Concepts

- **Animations** use motion and sound to explain concepts and can be played, paused, stopped, and replayed as many times as the student desires.
- **Simulations** encourage students to explore mathematical concepts experimentally.
- **Editable Graph Explorations** engage students in active discovery of mathematical concepts and relationships through the use of technology.



Trigonometry, Sixth Edition
Learning Tools Student CD-ROM

Selected examples and concepts throughout the text are identified by the Learning Tools Student CD-ROM icon. The chart on this and the following pages indicates the feature(s) of the CD—Guided Example, Synthesis Example, Animation, Simulation, and Editable Graph Exploration—that corresponds to the example or concept.

Chapter	Section	Example/Concept	Guided Example	Synthesis Example	Animation	Simulation	Editable Graph
P	1	Real Numbers	✓				
P	1	Ordering Real Numbers	✓				
P	1	Example 1	✓		✓		
P	1	Example 2	✓				
P	1	Absolute Value and Distance		✓			
P	1	Examples 4, 5	✓	✓			
P	1	Algebraic Expressions	✓		✓		
P	1	Basic Rules of Algebra	✓				
P	2	Solutions of Equations	✓	✓			
P	2	Examples 1, 4, 5, 10	✓	✓			
P	2	Quadratic Equations	✓				
P	2	Examples 6, 8, 9, 11, 12	✓				
P	2	Example 7			✓		
P	2	Example 10	✓	✓			
P	3	Examples 1, 3, 5, 8, 11	✓				
P	3	Example 2			✓		
P	3	Example 4		✓			
P	3	Example 6	✓		✓		
P	3	Example 7	✓				✓
P	3	Symmetry			✓		
P	3	Example 9		✓	✓		
P	3	Example 10		✓			✓
P	4	Using Slope	✓			✓	
P	4	Example 1		✓			
P	4	Examples 4, 5	✓	✓			
P	4	Examples 6, 7	✓				
P	4	Parallel and Perpendicular Lines	✓				
P	5	Examples 2, 6, 7, 9	✓				
P	5	Examples 3, 5	✓	✓			
P	6	Examples 1, 2	✓				
P	6	Examples 4, 6	✓	✓			
P	6	Even and Odd Functions				✓	
P	7	Example 2	✓				

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Chapter	Section	Example/Concept	Guided Example	Synthesis Example	Animation	Simulation	Editable Graph
P	7	Example 3		✓			
P	8	Shifting Graphs	✓		✓		
P	8	Example 1	✓				
P	8	Reflecting Graphs			✓		
P	8	Examples 2, 4		✓			
P	8	Nonrigid Transformations			✓		
P	9	Combinations of Functions	✓		✓		
P	9	Examples 2, 4, 5	✓				
P	9	Composition of Functions			✓		
P	9	Example 6		✓			
P	10	Examples 1, 2, 7	✓				
P	10	Graph of an Inverse Function			✓		
P	10	Examples 5, 6	✓	✓			
P	10	Finding Inverse Functions	✓				
1	1	Examples 1, 3, 4, 7	✓				
1	1	Example 2	✓		✓		
1	1	Degree Measure	✓	✓			
1	1	Example 5	✓			✓	
1	2	The Unit Circle		✓	✓		
1	2	The Trigonometric Functions			✓		
1	2	Examples 1–4	✓				
1	2	Domain and Period of Sine and Cosine	✓				
1	3	The Six Trigonometric Functions			✓		
1	3	Examples 1, 4, 7	✓	✓			
1	3	Example 3	✓		✓		
1	3	Example 6	✓				
1	4	Examples 1, 2, 5	✓				
1	4	Reference Angles				✓	
1	4	Examples 4, 7	✓	✓			
1	5	Amplitude and Period	✓				
1	5	Example 2		✓			✓
1	5	Example 4					✓
1	5	Example 5	✓		✓		
1	5	Example 6	✓				✓
1	5	Mathematical Modeling	✓				
1	6	Examples 1, 3–6	✓				
1	6	Example 2			✓		

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Chapter	Section	Example/Concept	Guided Example	Synthesis Example	Animation	Simulation	Editable Graph
1	6	Graphs of Reciprocal Functions					✓
1	7	Example 2			✓		
1	7	Other Inverse Trigonometric Functions		✓	✓		
1	7	Examples 3, 5, 6	✓				
1	7	Examples 4, 7	✓	✓			
1	8	Examples 1, 3, 5, 6	✓				
1	8	Example 4	✓	✓			
2	1	Examples 1–3, 5, 8	✓				
2	1	Example 4	✓	✓			
2	1	Example 6		✓			
2	2	Introduction			✓		
2	2	Examples 1, 3, 5	✓				
2	3	Examples 3, 4, 6, 8	✓				
2	3	Equations of Quadratic Type	✓				
2	3	Example 5		✓			
2	3	Functions Involving Multiple Angles		✓			
2	4	Sum and Difference Formulas		✓			
2	4	Examples 1, 3, 4, 8	✓				
2	4	Example 2		✓			
2	5	Multiple-Angle Formulas			✓		
2	5	Examples 1, 9	✓				
2	5	Example 3		✓			
2	5	Power-Reducing Formulas			✓		
2	5	Example 5	✓	✓			
2	5	Half-Angle Formulas			✓		
2	5	Example 6	✓	✓			
2	5	Product-To-Sum Formulas	✓				
3	1	Examples 1, 3, 5–7	✓				
3	1	The Ambiguous Case (SSA)				✓	
3	2	Example 1	✓	✓			
3	2	Examples 2, 4, 5	✓				
3	2	Example 3		✓			
3	3	Examples 2, 9	✓				
3	3	Vector Operations			✓		
3	3	Example 3	✓	✓	✓		
3	3	Unit Vectors	✓				

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Chapter	Section	Example/Concept	Guided Example	Synthesis Example	Animation	Simulation	Editable Graph
3	3	Examples 6, 7		✓			
3	3	Direction Angles		✓			
3	4	Examples 1, 2, 6, 8	✓				
3	4	Example 4	✓	✓			
3	4	Finding Vector Components				✓	
4	1	The Imaginary Unit *i*	✓				
4	1	Examples 1, 3, 4, 6	✓				
4	1	Examples 2, 5	✓	✓			
4	2	Examples 2, 3, 6	✓				
4	2	Example 5	✓	✓			
4	3	Examples 1, 2, 4	✓				
4	3	Example 5		✓			
4	3	Example 6	✓	✓			
4	4	Example 1	✓				
4	4	Example 3	✓	✓			
5	1	Example 2		✓			✓
5	1	Example 3	✓				✓
5	1	Example 4	✓	✓	✓		
5	1	Examples 5, 7, 8	✓				
5	1	Applications				✓	
5	2	Example 1	✓	✓			
5	2	Examples 2, 7, 8, 10	✓				
5	2	Example 4			✓		
5	2	Example 6	✓	✓	✓		
5	3	Examples 1, 2, 6	✓				
5	3	Example 4	✓	✓			
5	3	Example 5		✓			
5	4	Examples 1, 2, 4–8, 10	✓				
5	4	Example 3	✓	✓			
5	5	Example 1	✓	✓			
5	5	Examples 2, 3, 5, 6	✓				
6	1	Inclination of a Line				✓	
6	1	Example 1	✓	✓			
6	1	The Angle Between Two Lines				✓	
6	1	Examples 2–4	✓				
6	2	Conics			✓		
6	2	Examples 1, 2, 4	✓				
6	2	Example 3	✓	✓			