4.3 Exercises

See CalcChat.com for tutorial help and worked-out solutions to odd-numbered exercises.

Vocabulary

1. Match each trigonometric function with its right triangle definition.

(a) sine (b) cosine (c) tangent (d) cosecant (e) secant (f) cotangent

(i) $\dfrac{\text{hypotenuse}}{\text{adjacent}}$ (ii) $\dfrac{\text{adjacent}}{\text{opposite}}$ (iii) $\dfrac{\text{hypotenuse}}{\text{opposite}}$ (iv) $\dfrac{\text{adjacent}}{\text{hypotenuse}}$ (v) $\dfrac{\text{opposite}}{\text{hypotenuse}}$ (vi) $\dfrac{\text{opposite}}{\text{adjacent}}$

In Exercises 2–4, fill in the blanks.

2. Relative to the acute angle θ, the three sides of a right triangle are the ________ side, the ________ side, and the ________.
3. Cofunctions of ________ angles are equal.
4. An angle of ________ represents the angle from the horizontal upward to an object, whereas an angle of ________ represents the angle from the horizontal downward to an object.

Skills and Applications

Evaluating Trigonometric Functions **In Exercises 5–10, find the exact values of the six trigonometric functions of the angle θ.**

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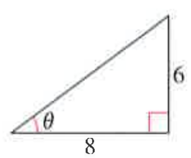

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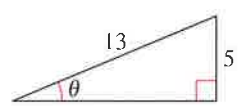

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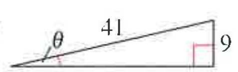

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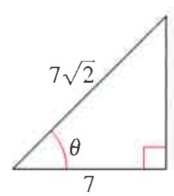

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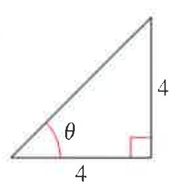

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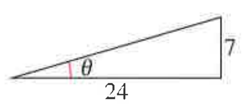

Evaluating Trigonometric Functions **In Exercises 11–14, find the exact values of the six trigonometric functions of the angle θ for each of the two triangles. Explain why the function values are the same.**

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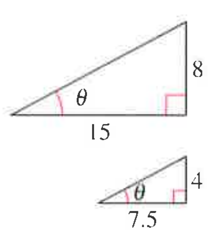

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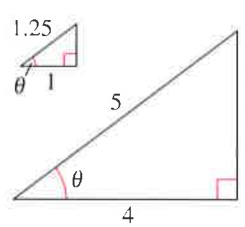

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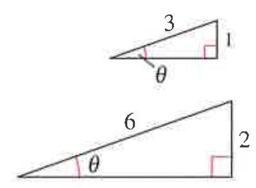

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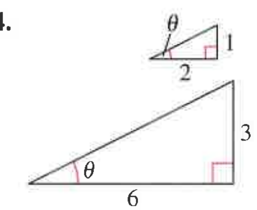


Evaluating Trigonometric Functions **In Exercises 15–22, sketch a right triangle corresponding to the trigonometric function of the acute angle θ. Then find the exact values of the other five trigonometric functions of θ.**

15. $\cos\theta = \frac{15}{17}$
16. $\sin\theta = \frac{3}{5}$
17. $\sec\theta = \frac{6}{5}$
18. $\tan\theta = \frac{4}{5}$
19. $\sin\theta = \frac{1}{5}$
20. $\sec\theta = \frac{17}{7}$
21. $\cot\theta = 3$
22. $\csc\theta = 9$

Evaluating Trigonometric Functions of 30°, 45°, and 60° **In Exercises 23–28, construct an appropriate triangle to find the missing values. ($0° \le \theta \le 90°$, $0 \le \theta \le \pi/2$)**

	Function	θ (deg)	θ (rad)	Function Value
23.	tan	30°		
24.	cos	45°		
25.	sin		$\frac{\pi}{4}$	
26.	tan		$\frac{\pi}{3}$	
27.	sec		$\frac{\pi}{4}$	
28.	csc		$\frac{\pi}{6}$	

Using a Calculator **In Exercises 29–36, use a calculator to evaluate each function. Round your answers to four decimal places. (Be sure the calculator is in the correct mode.)**

29. (a) $\sin 20°$ (b) $\cos 70°$
30. (a) $\tan 23.5°$ (b) $\cot 66.5°$
31. (a) $\sin 14.21°$ (b) $\csc 14.21°$
32. (a) $\cot 79.56°$ (b) $\sec 79.56°$
33. (a) $\cos 4° 50' 15''$ (b) $\sec 4° 50' 15''$
34. (a) $\sec 42° 12'$ (b) $\csc 48° 7'$
35. (a) $\cot 17° 15'$ (b) $\tan 17° 15'$
36. (a) $\sec 56° 8' 10''$ (b) $\cos 56° 8' 10''$

Applying Trigonometric Identities **In Exercises 37–42, use the given function value(s) and the trigonometric identities to find the exact value of each indicated trigonometric function.**

37. $\sin 60° = \dfrac{\sqrt{3}}{2}$, $\cos 60° = \dfrac{1}{2}$
(a) $\sin 30°$ (b) $\cos 30°$
(c) $\tan 60°$ (d) $\cot 60°$

38. $\sin 30° = \dfrac{1}{2}$, $\tan 30° = \dfrac{\sqrt{3}}{3}$
(a) $\csc 30°$ (b) $\cot 60°$
(c) $\cos 30°$ (d) $\cot 30°$

39. $\cos\theta = \frac{1}{3}$
(a) $\sin\theta$ (b) $\tan\theta$
(c) $\sec\theta$ (d) $\csc(90° - \theta)$

40. $\sec\theta = 5$
(a) $\cos\theta$ (b) $\cot\theta$
(c) $\cot(90° - \theta)$ (d) $\sin\theta$

41. $\cot\alpha = 3$
(a) $\tan\alpha$ (b) $\csc\alpha$
(c) $\cot(90° - \alpha)$ (d) $\sin\alpha$

42. $\cos\beta = \dfrac{\sqrt{7}}{4}$
(a) $\sec\beta$ (b) $\sin\beta$
(c) $\cot\beta$ (d) $\sin(90° - \beta)$

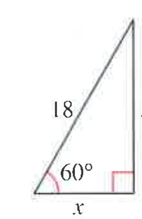
Using Trigonometric Identities **In Exercises 43–52, use trigonometric identities to transform the left side of the equation into the right side ($0 < \theta < \pi/2$).**

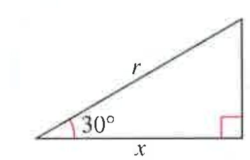
43. $\tan\theta\cot\theta = 1$
44. $\cos\theta\sec\theta = 1$
45. $\tan\alpha\cos\alpha = \sin\alpha$
46. $\cot\alpha\sin\alpha = \cos\alpha$
47. $(1 + \sin\theta)(1 - \sin\theta) = \cos^2\theta$
48. $(1 + \cos\theta)(1 - \cos\theta) = \sin^2\theta$
49. $(\sec\theta + \tan\theta)(\sec\theta - \tan\theta) = 1$
50. $\sin^2\theta - \cos^2\theta = 2\sin^2\theta - 1$
51. $\dfrac{\sin\theta}{\cos\theta} + \dfrac{\cos\theta}{\sin\theta} = \csc\theta\sec\theta$
52. $\dfrac{\tan\beta + \cot\beta}{\tan\beta} = \csc^2\beta$

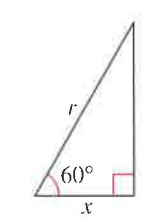
Finding Special Angles of a Triangle **In Exercises 53–58, find each value of θ in degrees ($0° < \theta < 90°$) and radians ($0 < \theta < \pi/2$) without using a calculator.**

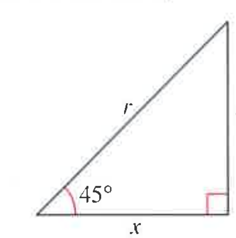
53. (a) $\sin\theta = \frac{1}{2}$ (b) $\csc\theta = 2$
54. (a) $\cos\theta = \dfrac{\sqrt{2}}{2}$ (b) $\tan\theta = 1$
55. (a) $\sec\theta = 2$ (b) $\cot\theta = 1$
56. (a) $\tan\theta = \sqrt{3}$ (b) $\csc\theta = \sqrt{2}$
57. (a) $\csc\theta = \dfrac{2\sqrt{3}}{3}$ (b) $\sin\theta = \dfrac{\sqrt{2}}{2}$
58. (a) $\cot\theta = \dfrac{\sqrt{3}}{3}$ (b) $\sec\theta = \sqrt{2}$

Finding Side Lengths of a Triangle **In Exercises 59–62, find the exact values of the indicated variables.**

59. Find x and y.


60. Find x and r.


61. Find x and r.


62. Find x and r.


63. **Empire State Building** You are standing 45 meters from the base of the Empire State Building. You estimate that the angle of elevation to the top of the 86th floor (the observatory) is 82°. The total height of the building is another 123 meters above the 86th floor. What is the approximate height of the building? One of your friends is on the 86th floor. What is the distance between you and your friend?

64. Height of a Tower A six-foot person walks from the base of a broadcasting tower directly toward the tip of the shadow cast by the tower. When the person is 132 feet from the tower and 3 feet from the tip of the shadow, the person's shadow starts to appear beyond the tower's shadow.

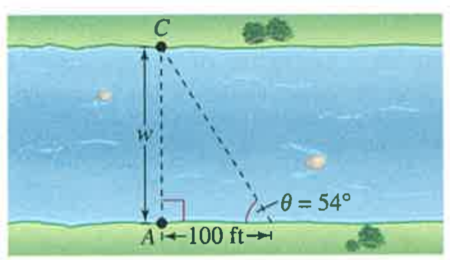
(a) Draw a right triangle that gives a visual representation of the problem. Label the known quantities of the triangle and use a variable to represent the height of the tower.

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

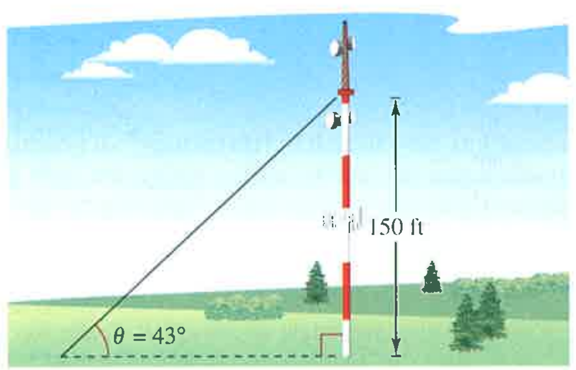
(c) What is the height of the tower?

65. Angle of Elevation You are skiing down a mountain with a vertical height of 1250 feet. The distance from the top of the mountain to the base is 2500 feet. What is the angle of elevation from the base to the top of the mountain?

66. Biology A biologist wants to know the width w of a river to properly set instruments for an experiment. 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?



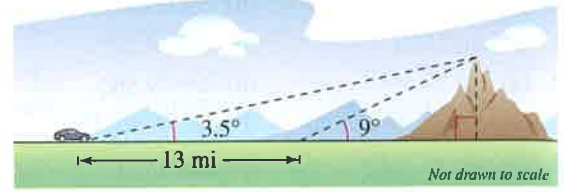
67. Guy Wire A guy wire runs from the ground to a cell tower. The wire is attached to the cell tower 150 feet above the ground. The angle formed between the wire and the ground is 43° (see figure).



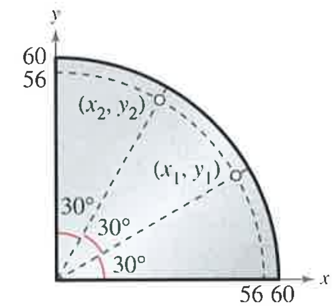
(a) How long is the guy wire?

(b) How far from the base of the tower is the guy wire anchored to the ground?

68. Height of a Mountain In traveling across flat land, you see 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° (see figure). Approximate the height of the mountain.



69. 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 drilled in the plate, positioned as shown in the figure. Find the coordinates of the center of each hole.



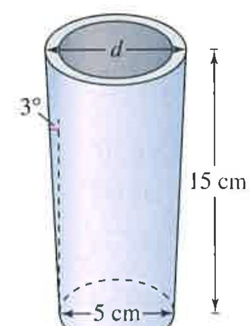
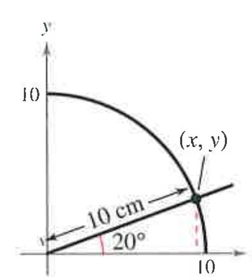


Figure for 69 Figure for 70

70. Machine Shop Calculations A tapered shaft has a diameter of 5 centimeters at the small end and is 15 centimeters long (see figure). The taper is 3°. Find the diameter d of the large end of the shaft.

71. Geometry Use a compass to sketch a quarter of a circle of radius 10 centimeters. Using a protractor, construct an angle of 20° in standard position (see figure). Drop a perpendicular line from the point of intersection of the terminal side of the angle and the arc of the circle. By actual measurement, calculate the coordinates (x, y) of the point of intersection and use these measurements to approximate the six trigonometric functions of a 20° angle.



72. Helium-Filled Balloon A 20-meter line is used to tether a helium-filled balloon. The line makes an angle of approximately 85° with the ground because of a breeze.

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

(b) Use a trigonometric function to write and solve an equation for the height of the balloon.

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

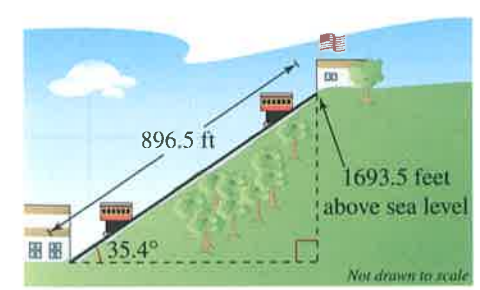
(d) Complete the table, which shows the heights (in meters) of the balloon for decreasing angle measures θ.

Angle, θ	80°	70°	60°	50°
Height				

Angle, θ	40°	30°	20°	10°
Height				

(e) As θ approaches 0°, how does this affect the height of the balloon? Draw a right triangle to explain your reasoning.

73. Johnstown Inclined Plane The Johnstown Inclined Plane in Pennsylvania is one of the longest and steepest hoists in the world. The railway cars travel a distance of 896.5 feet at an angle of approximately 35.4°, rising to a height of 1693.5 feet above sea level.



(a) Find the vertical rise of the inclined plane.

(b) Find the elevation of the lower end of the inclined plane.

(c) The cars move up the mountain at a rate of 300 feet per minute. Find the rate at which they rise vertically.

74. Error Analysis Describe the error.

$$\cos 60° = \frac{\text{opp}}{\text{hyp}} = \frac{1}{2}$$ X

Exploration

True or False? **In Exercises 75–80, determine whether the statement is true or false. Justify your answer.**

75. $\sin 60° \csc 60° = 1$

76. $\sec 30° = \csc 30°$

77. $\sin 45° + \cos 45° = 1$

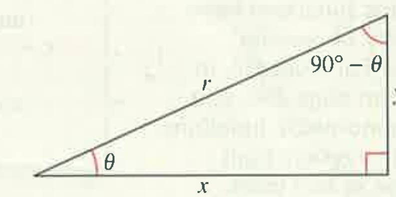
78. $\cos 60° - \sin 30° = 0$

79. $\dfrac{\sin 60°}{\sin 30°} = \sin 2°$

80. $\tan[(5°)^2] = \tan^2 5°$

81. Think About It You are given the value of $\tan \theta$. Is it possible to find the value of $\sec \theta$ without finding the measure of θ? Explain.

82. HOW DO YOU SEE IT? Use the figure below.



(a) Which side is opposite θ?

(b) Which side is adjacent to $90° - \theta$?

(c) Explain why $\sin \theta = \cos(90° - \theta)$.

83. Think About It Complete the table.

θ	0.1	0.2	0.3	0.4	0.5
$\sin \theta$					

(a) Is θ or $\sin \theta$ greater for θ in the interval $(0, 0.5]$?

(b) As θ approaches 0, how do θ and $\sin \theta$ compare? Explain.

84. Think About It Complete the table.

θ	0°	18°	36°	54°	72°	90°
$\sin \theta$						
$\cos \theta$						

(a) Discuss the behavior of the sine function for $0° \le \theta \le 90°$.

(b) Discuss the behavior of the cosine function for $0° \le \theta \le 90°$.

(c) Use the definitions of the sine and cosine functions to explain the results of parts (a) and (b).