Quadrants and angles

1. In which quadrant would you find the angle $\theta = 179^\circ$?
   (a) I    (b) II    (c) III    (d) IV

2. In which quadrant would you find the angle $\theta = 235^\circ$?
   (a) I    (b) II    (c) III    (d) IV

3. In which quadrant would you find the angle $\theta = 335^\circ$?
   (a) I    (b) II    (c) III    (d) IV

4. In which quadrant would you find the angle $\theta = 79^\circ$?
   (a) I    (b) II    (c) III    (d) IV

5. In which quadrant would you find the angle $\theta = 176^\circ$?
   (a) I    (b) II    (c) III    (d) IV

6. In which quadrant would you find the angle $\theta = 288^\circ$?
   (a) I    (b) II    (c) III    (d) IV

7. In which quadrant would you find the angle $\theta = \frac{6\pi}{5}$ radians?
   (a) I    (b) II    (c) III    (d) IV

8. In which quadrant would you find the angle $\theta = \frac{9\pi}{7}$ radians?
   (a) I    (b) II    (c) III    (d) IV

9. In which quadrant would you find the angle $\theta = \frac{7\pi}{9}$ radians?
   (a) I    (b) II    (c) III    (d) IV

10. In which quadrant would you find the angle $\theta = \frac{\pi}{7}$ radians?
    (a) I    (b) II    (c) III    (d) IV

11. In which quadrant would you find the angle $\theta = \frac{9\pi}{5}$ radians?
    (a) I    (b) II    (c) III    (d) IV

12. In which quadrant would you find the angle $\theta = \frac{3\pi}{5}$ radians?
    (a) I    (b) II    (c) III    (d) IV
13. In which quadrant would you find the angle \( \theta = 2.2 \) radians?
(a) I    (b) II    (c) III    (d) IV

14. In which quadrant would you find the angle \( \theta = 3.6 \) radians?
(a) I    (b) II    (c) III    (d) IV

15. In which quadrant would you find the angle \( \theta = 1.8 \) radians?
(a) I    (b) II    (c) III    (d) IV

16. In which quadrant would you find the angle \( \theta = 5.2 \) radians?
(a) I    (b) II    (c) III    (d) IV

17. In which quadrant would you find the angle \( \theta = 4.3 \) radians?
(a) I    (b) II    (c) III    (d) IV

18. In which quadrant would you find the angle \( \theta = 1.4 \) radians?
(a) I    (b) II    (c) III    (d) IV

19. Suppose \( \theta \) is an acute angle. In which quadrant would you find \( 90^\circ - \theta \)?
(a) I    (b) II    (c) III    (d) IV

20. Suppose \( \theta \) is an acute angle. In which quadrant would you find \( 90^\circ + \theta \)?
(a) I    (b) II    (c) III    (d) IV

21. Suppose \( \theta \) is an acute angle. In which quadrant would you find \( -\theta \)?
(a) I    (b) II    (c) III    (d) IV

22. Suppose \( \theta \) is an acute angle. In which quadrant would you find \( 180^\circ - \theta \)?
(a) I    (b) II    (c) III    (d) IV

23. Suppose \( \theta \) is an acute angle. In which quadrant would you find \( 180^\circ + \theta \)?
(a) I    (b) II    (c) III    (d) IV

24. Suppose \( \theta \) is an acute angle. In which quadrant would you find \( 360^\circ + \theta \)?
(a) I    (b) II    (c) III    (d) IV

25. Suppose \( \theta \) is an acute angle. In which quadrant would you find \( 270^\circ + \theta \)?
(a) I    (b) II    (c) III    (d) IV

26. Suppose \( \theta \) is an acute angle. In which quadrant would you find \( 270^\circ - \theta \)?
(a) I    (b) II    (c) III    (d) IV

27. Suppose \( \theta \) is an acute angle. In which quadrant would you find \( \frac{\pi}{2} + \theta \) radians?
(a) I    (b) II    (c) III    (d) IV
28. Suppose $\theta$ is an acute angle. In which quadrant would you find $\pi + \theta$ radians?
(a) I  (b) II  (c) III  (d) IV

29. Suppose $\theta$ is an acute angle. In which quadrant would you find $\frac{\pi}{2} - \theta$ radians?
(a) I  (b) II  (c) III  (d) IV

30. Suppose $\theta$ is an acute angle. In which quadrant would you find $\frac{3\pi}{2} - \theta$ radians?
(a) I  (b) II  (c) III  (d) IV

31. Suppose $\theta$ is an acute angle. In which quadrant would you find $\frac{3\pi}{2} + \theta$ radians?
(a) I  (b) II  (c) III  (d) IV

32. Suppose $\theta$ is an acute angle. In which quadrant would you find $\pi - \theta$ radians?
(a) I  (b) II  (c) III  (d) IV

33. Suppose $\theta$ is an acute angle. In which quadrant would you find $2\pi + \theta$ radians?
(a) I  (b) II  (c) III  (d) IV

34. If the angle $\theta$ is in quadrant I, which of the following is true?
(a) $\sin \theta > 0$, $\cos \theta > 0$  (b) $\sin \theta > 0$, $\cos \theta < 0$
(c) $\sin \theta < 0$, $\cos \theta > 0$  (d) $\sin \theta < 0$, $\cos \theta < 0$

35. If the angle $\theta$ is in quadrant II, which of the following is true?
(a) $\sin \theta > 0$, $\cos \theta > 0$  (b) $\sin \theta > 0$, $\cos \theta < 0$
(c) $\sin \theta < 0$, $\cos \theta > 0$  (d) $\sin \theta < 0$, $\cos \theta < 0$

36. If the angle $\theta$ is in quadrant III, which of the following is true?
(a) $\sin \theta > 0$, $\cos \theta > 0$  (b) $\sin \theta > 0$, $\cos \theta < 0$
(c) $\sin \theta < 0$, $\cos \theta > 0$  (d) $\sin \theta < 0$, $\cos \theta < 0$

37. If the angle $\theta$ is in quadrant IV, which of the following is true?
(a) $\sin \theta > 0$, $\cos \theta > 0$  (b) $\sin \theta > 0$, $\cos \theta < 0$
(c) $\sin \theta < 0$, $\cos \theta > 0$  (d) $\sin \theta < 0$, $\cos \theta < 0$

38. If $\sin \theta > 0$, which quadrant could $\theta$ be in?
(a) I or II  (b) I or III  (c) I or IV
(d) II or III  (e) II or IV  (f) III or IV

39. If $\cos \theta > 0$, which quadrant could $\theta$ be in?
(a) I or II  (b) I or III  (c) I or IV
(d) II or III  (e) II or IV  (f) III or IV
40. If \( \tan \theta > 0 \), which quadrant could \( \theta \) be in?
(a) I or II (b) I or III (c) I or IV (d) II or III (e) II or IV (f) III or IV

41. Suppose \( \theta \) is an acute angle. Which of the following must be true?
(a) \( \sin(180^\circ - \theta) = \sin \theta \) (b) \( \sin(180^\circ + \theta) = \sin \theta \) (c) \( \sin(90^\circ + \theta) = \sin 0 \)
(d) \( \sin(-\theta) = \sin \theta \) (e) \( \sin(90^\circ - \theta) = \sin \theta \) (f) \( \sin(270^\circ - \theta) = \sin \theta \)

42. Suppose \( \theta \) is an acute angle. Which of the following must be true?
(a) \( \cos(180^\circ - \theta) = \cos \theta \) (b) \( \cos(180^\circ + \theta) = \cos \theta \) (c) \( \cos(90^\circ + \theta) = \cos \theta \)
(d) \( \cos(-\theta) = \cos \theta \) (e) \( \cos(90^\circ - \theta) = \cos \theta \) (f) \( \cos(270^\circ - \theta) = \cos \theta \)

43. Suppose \( \theta \) is an acute angle. Which of the following must be true?
(a) \( \tan(180^\circ - \theta) = \tan \theta \) (b) \( \tan(180^\circ + \theta) = \tan \theta \) (c) \( \tan(90^\circ + \theta) = \tan \theta \)
(d) \( \tan(-\theta) = \tan \theta \) (e) \( \tan(90^\circ - \theta) = \tan \theta \) (f) \( \tan(270^\circ - \theta) = \tan \theta \)

44. Suppose \( \phi \) is an acute angle in radians. Which of the following must be true?
(a) \( \sin(-\phi) = \sin \phi \) (b) \( \sin\left(\frac{\pi}{2} - \phi\right) = \sin \phi \) (c) \( \sin\left(\frac{\pi}{2} + \phi\right) = \sin \phi \)
(d) \( \sin\left(\frac{3\pi}{2} + \phi\right) = \sin \phi \) (e) \( \sin(\pi - \phi) = \sin \phi \) (f) \( \sin(\pi + \phi) = \sin \phi \)

45. Suppose \( \phi \) is an acute angle in radians. Which of the following must be true?
(a) \( \cos(-\phi) = \cos \phi \) (b) \( \cos\left(\frac{\pi}{2} - \phi\right) = \cos \phi \) (c) \( \cos\left(\frac{\pi}{2} + \phi\right) = \cos \phi \)
(d) \( \cos\left(\frac{3\pi}{2} + \phi\right) = \cos \phi \) (e) \( \cos(\pi - \phi) = \cos \phi \) (f) \( \cos(\pi + \phi) = \cos \phi \)

46. Suppose \( \phi \) is an acute angle in radians. Which of the following must be true?
(a) \( \tan(-\phi) = \tan \phi \) (b) \( \tan\left(\frac{\pi}{2} - \phi\right) = \tan \phi \) (c) \( \tan\left(\frac{\pi}{2} + \phi\right) = \tan \phi \)
(d) \( \tan\left(\frac{3\pi}{2} + \phi\right) = \tan \phi \) (e) \( \tan(\pi - \phi) = \tan \phi \) (f) \( \tan(\pi + \phi) = \tan \phi \)
Trigonometric functions of common angles
You should not use a calculator for these. Give your answers in terms of fractions and/or square roots, and rationalize all denominators.

47. If \( \theta = 120^\circ \), what is \( \sin \theta \)?

48. If \( \theta = 210^\circ \), what is \( \tan \theta \)?

49. If \( \theta = 210^\circ \), what is \( \sin \theta \)?

50. If \( \theta = 180^\circ \), what is \( \tan \theta \)?

51. If \( \theta = 330^\circ \), what is \( \sin \theta \)?

52. If \( \theta = 45^\circ \), what is \( \tan \theta \)?

53. If \( \theta = 330^\circ \), what is \( \tan \theta \)?

54. If \( \theta = 60^\circ \), what is \( \tan \theta \)?

55. If \( \theta = 150^\circ \), what is \( \cos \theta \)?

56. If \( \theta = 150^\circ \), what is \( \sin \theta \)?

57. If \( \theta = 180^\circ \), what is \( \cos \theta \)?

58. If \( \theta = 30^\circ \), what is \( \sin \theta \)?

59. If \( \theta = 300^\circ \), what is \( \sin \theta \)?

60. If \( \theta = 240^\circ \), what is \( \sin \theta \)?

61. If \( \theta = 0^\circ \), what is \( \sin \theta \)?

62. If \( \theta = 210^\circ \), what is \( \cos \theta \)?

63. If \( \theta = 60^\circ \), what is \( \sin \theta \)?

64. If \( \theta = 150^\circ \), what is \( \tan \theta \)?

65. If \( \theta = 90^\circ \), what is \( \tan \theta \)?

66. If \( \theta = 300^\circ \), what is \( \tan \theta \)?

67. If \( \theta = 300^\circ \), what is \( \cos \theta \)?
68. If $\theta = 180^\circ$, what is $\sin \theta$?
69. If $\theta = 135^\circ$, what is $\sin \theta$?
70. If $\theta = 30^\circ$, what is $\tan \theta$?
71. If $\theta = 7\pi/6$ radians, what is $\cos \theta$?
72. If $\theta = 3\pi/4$ radians, what is $\tan \theta$?
73. If $\theta = \pi/3$ radians, what is $\tan \theta$?
74. If $\theta = \pi/6$ radians, what is $\tan \theta$?
75. If $\theta = 2\pi/3$ radians, what is $\sin \theta$?
76. If $\theta = \pi/2$ radians, what is $\tan \theta$?
77. If $\theta = 5\pi/4$ radians, what is $\cos \theta$?
78. If $\theta = 4\pi/3$ radians, what is $\cos \theta$?
79. If $\theta = 5\pi/6$ radians, what is $\sin \theta$?
80. If $\theta = 7\pi/6$ radians, what is $\sin \theta$?
81. If $\theta = 3\pi/4$ radians, what is $\cos \theta$?
82. If $\theta = 5\pi/3$ radians, what is $\tan \theta$?
83. If $\theta = 2\pi/3$ radians, what is $\tan \theta$?
84. If $\theta = 0$ radians, what is $\cos \theta$?
85. If $\theta = 5\pi/4$ radians, what is $\sin \theta$?
86. If $\theta = 5\pi/4$ radians, what is $\tan \theta$?
87. If $\theta = 7\pi/4$ radians, what is $\tan \theta$?
88. If $\theta = 7\pi/4$ radians, what is $\sin \theta$?
89. If $\theta = \pi/3$ radians, what is $\cos \theta$?
90. If $\theta = 4\pi/3$ radians, what is $\sin \theta$?
91. If $\theta = 5\pi/3$ radians, what is $\cos \theta$?

92. If $\theta = \pi/6$ radians, what is $\cos \theta$?

93. If $\theta = \pi$ radians, what is $\tan \theta$?

94. If $\theta = 2\pi/3$ radians, what is $\cos \theta$?

**Reference angles**

95. $\cos 229^\circ = ?$
   (a) $\cos 49^\circ$  (b) $-\cos 49^\circ$  (c) $\cos 41^\circ$  (d) $-\cos 41^\circ$

96. $\tan (-74)^\circ = ?$
   (a) $\tan 74^\circ$  (b) $-\tan 74^\circ$  (c) $\tan 16^\circ$  (d) $-\tan 16^\circ$

97. $\cos 195^\circ = ?$
   (a) $\cos 75^\circ$  (b) $-\cos 75^\circ$  (c) $\cos 15^\circ$  (d) $-\cos 15^\circ$

98. $\sin 191^\circ = ?$
   (a) $\sin 79^\circ$  (b) $-\sin 79^\circ$  (c) $\sin 11^\circ$  (d) $-\sin 11^\circ$

99. $\tan 229^\circ = ?$
   (a) $\tan 49^\circ$  (b) $-\tan 49^\circ$  (c) $\tan 41^\circ$  (d) $-\tan 41^\circ$

100. $\sin 152^\circ = ?$
    (a) $\sin 62^\circ$  (b) $-\sin 62^\circ$  (c) $\sin 28^\circ$  (d) $-\sin 28^\circ$

101. $\sin 284^\circ = ?$
    (a) $\sin 76^\circ$  (b) $-\sin 76^\circ$  (c) $\sin 14^\circ$  (d) $-\sin 14^\circ$

102. $\cos (-18)^\circ = ?$
    (a) $\cos 72^\circ$  (b) $-\cos 72^\circ$  (c) $\cos 18^\circ$  (d) $-\cos 18^\circ$

103. $\sin (-42)^\circ = ?$
    (a) $\sin 48^\circ$  (b) $-\sin 48^\circ$  (c) $\sin 42^\circ$  (d) $-\sin 42^\circ$

104. $\sin 350^\circ = ?$
    (a) $\sin 80^\circ$  (b) $-\sin 80^\circ$  (c) $\sin 10^\circ$  (d) $-\sin 10^\circ$

105. $\sin (-48)^\circ = ?$
    (a) $\sin 48^\circ$  (b) $-\sin 48^\circ$  (c) $\sin 42^\circ$  (d) $-\sin 42^\circ$

106. $\tan 234^\circ = ?$
    (a) $\tan 54^\circ$  (b) $-\tan 54^\circ$  (c) $\tan 36^\circ$  (d) $-\tan 36^\circ$
107. \( \tan 299^\circ = ? \)
   (a) \( \tan 61^\circ \)  
   (b) \(-\tan 61^\circ\)  
   (c) \( \tan 29^\circ \)  
   (d) \(-\tan 29^\circ\) 

108. \( \sin 177^\circ = ? \)
   (a) \( \sin 87^\circ \)  
   (b) \(-\sin 87^\circ\)  
   (c) \( \sin 3^\circ \)  
   (d) \(-\sin 3^\circ\) 

109. \( \tan 349^\circ = ? \)
   (a) \( \tan 79^\circ \)  
   (b) \(-\tan 79^\circ\)  
   (c) \( \tan 11^\circ \)  
   (d) \(-\tan 11^\circ\) 

110. \( \cos 167^\circ = ? \)
   (a) \( \cos 77^\circ \)  
   (b) \(-\cos 77^\circ\)  
   (c) \( \cos 13^\circ \)  
   (d) \(-\cos 13^\circ\) 

111. \( \tan 132^\circ = ? \)
   (a) \( \tan 48^\circ \)  
   (b) \(-\tan 48^\circ\)  
   (c) \( \tan 42^\circ \)  
   (d) \(-\tan 42^\circ\) 

112. \( \sin 211^\circ = ? \)
   (a) \( \sin 59^\circ \)  
   (b) \(-\sin 59^\circ\)  
   (c) \( \sin 31^\circ \)  
   (d) \(-\sin 31^\circ\) 

113. \( \sin (-80)^\circ = ? \)
   (a) \( \sin 80^\circ \)  
   (b) \(-\sin 80^\circ\)  
   (c) \( \sin 10^\circ \)  
   (d) \(-\sin 10^\circ\) 

114. \( \sin (-16)^\circ = ? \)
   (a) \( \sin 74^\circ \)  
   (b) \(-\sin 74^\circ\)  
   (c) \( \sin 16^\circ \)  
   (d) \(-\sin 16^\circ\) 

115. \( \cos (-21)^\circ = ? \)
   (a) \( \cos 69^\circ \)  
   (b) \(-\cos 69^\circ\)  
   (c) \( \cos 21^\circ \)  
   (d) \(-\cos 21^\circ\) 

116. \( \cos 101^\circ = ? \)
   (a) \( \cos 79^\circ \)  
   (b) \(-\cos 79^\circ\)  
   (c) \( \cos 11^\circ \)  
   (d) \(-\cos 11^\circ\) 

117. \( \cos 211^\circ = ? \)
   (a) \( \cos 59^\circ \)  
   (b) \(-\cos 59^\circ\)  
   (c) \( \cos 31^\circ \)  
   (d) \(-\cos 31^\circ\) 

118. \( \tan 244^\circ = ? \)
   (a) \( \tan 64^\circ \)  
   (b) \(-\tan 64^\circ\)  
   (c) \( \tan 26^\circ \)  
   (d) \(-\tan 26^\circ\) 

119. \( \sin 348^\circ = ? \)
   (a) \( \sin 78^\circ \)  
   (b) \(-\sin 78^\circ\)  
   (c) \( \sin 12^\circ \)  
   (d) \(-\sin 12^\circ\) 

120. \( \sin 189^\circ = ? \)
   (a) \( \sin 81^\circ \)  
   (b) \(-\sin 81^\circ\)  
   (c) \( \sin 9^\circ \)  
   (d) \(-\sin 9^\circ\) 

121. \( \sin 293^\circ = ? \)
   (a) \( \sin 67^\circ \)  
   (b) \(-\sin 67^\circ\)  
   (c) \( \sin 23^\circ \)  
   (d) \(-\sin 23^\circ\)
122. \( \cos 151^\circ = ? \)
(a) \( \cos 61^\circ \)  
(b) \( -\cos 61^\circ \)  
(c) \( \cos 29^\circ \)  
(d) \( -\cos 29^\circ \)

123. \( \cos 338^\circ = ? \)
(a) \( \cos 68^\circ \)  
(b) \( -\cos 68^\circ \)  
(c) \( \cos 22^\circ \)  
(d) \( -\cos 22^\circ \)

124. \( \tan 200^\circ = ? \)
(a) \( \tan 70^\circ \)  
(b) \( -\tan 70^\circ \)  
(c) \( \tan 20^\circ \)  
(d) \( -\tan 20^\circ \)

125. \( \sin \left(\frac{6\pi}{11}\right) = ? \)
(a) \( \sin \left(\frac{\pi}{22}\right) \)  
(b) \( -\sin \left(\frac{\pi}{22}\right) \)  
(c) \( \sin \left(\frac{5\pi}{11}\right) \)  
(d) \( -\sin \left(\frac{5\pi}{11}\right) \)

126. \( \tan \left(\frac{3\pi}{5}\right) = ? \)
(a) \( \tan \left(\frac{\pi}{10}\right) \)  
(b) \( -\tan \left(\frac{\pi}{10}\right) \)  
(c) \( \tan \left(\frac{2\pi}{5}\right) \)  
(d) \( -\tan \left(\frac{2\pi}{5}\right) \)

127. \( \cos \left(\frac{7\pi}{5}\right) = ? \)
(a) \( \cos \left(\frac{2\pi}{5}\right) \)  
(b) \( -\cos \left(\frac{2\pi}{5}\right) \)  
(c) \( \cos \left(\frac{\pi}{10}\right) \)  
(d) \( -\cos \left(\frac{\pi}{10}\right) \)

128. \( \cos \left(-\frac{3\pi}{7}\right) = ? \)
(a) \( \cos \left(\frac{3\pi}{7}\right) \)  
(b) \( -\cos \left(\frac{3\pi}{7}\right) \)  
(c) \( \cos \left(\frac{\pi}{14}\right) \)  
(d) \( -\cos \left(\frac{\pi}{14}\right) \)

129. \( \cos \left(\frac{4\pi}{5}\right) = ? \)
(a) \( \cos \left(\frac{3\pi}{10}\right) \)  
(b) \( -\cos \left(\frac{3\pi}{10}\right) \)  
(c) \( \cos \left(\frac{\pi}{5}\right) \)  
(d) \( -\cos \left(\frac{\pi}{5}\right) \)

130. \( \cos \left(-\frac{2\pi}{11}\right) = ? \)
(a) \( \cos \left(\frac{2\pi}{11}\right) \)  
(b) \( -\cos \left(\frac{2\pi}{11}\right) \)  
(c) \( \cos \left(\frac{7\pi}{22}\right) \)  
(d) \( -\cos \left(\frac{7\pi}{22}\right) \)

131. \( \cos \left(\frac{10\pi}{7}\right) = ? \)
(a) \( \cos \left(\frac{3\pi}{7}\right) \)  
(b) \( -\cos \left(\frac{3\pi}{7}\right) \)  
(c) \( \cos \left(\frac{\pi}{14}\right) \)  
(d) \( -\cos \left(\frac{\pi}{14}\right) \)

132. \( \cos \left(-\frac{\pi}{11}\right) = ? \)
(a) \( \cos \left(\frac{\pi}{11}\right) \)  
(b) \( -\cos \left(\frac{\pi}{11}\right) \)  
(c) \( \cos \left(\frac{9\pi}{22}\right) \)  
(d) \( -\cos \left(\frac{9\pi}{22}\right) \)

133. \( \sin \left(\frac{9\pi}{7}\right) = ? \)
(a) \( \sin \left(\frac{2\pi}{7}\right) \)  
(b) \( -\sin \left(\frac{2\pi}{7}\right) \)  
(c) \( \sin \left(\frac{3\pi}{14}\right) \)  
(d) \( -\sin \left(\frac{3\pi}{14}\right) \)

134. \( \cos \left(\frac{8\pi}{5}\right) = ? \)
(a) \( \cos \left(\frac{2\pi}{5}\right) \)  
(b) \( -\cos \left(\frac{2\pi}{5}\right) \)  
(c) \( \cos \left(\frac{\pi}{10}\right) \)  
(d) \( -\cos \left(\frac{\pi}{10}\right) \)

135. \( \cos \left(\frac{6\pi}{7}\right) = ? \)
(a) \( \cos \left(\frac{\pi}{7}\right) \)  
(b) \( -\cos \left(\frac{\pi}{7}\right) \)  
(c) \( \cos \left(\frac{5\pi}{14}\right) \)  
(d) \( -\cos \left(\frac{5\pi}{14}\right) \)

136. \( \sin \left(-\frac{5\pi}{11}\right) = ? \)
(a) \( \sin \left(\frac{5\pi}{11}\right) \)  
(b) \( -\sin \left(\frac{5\pi}{11}\right) \)  
(c) \( \sin \left(\frac{\pi}{22}\right) \)  
(d) \( -\sin \left(\frac{\pi}{22}\right) \)
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<td>140.</td>
<td>( \tan \left( \frac{-3\pi}{11} \right) = ? )</td>
<td>(a) ( \tan \left( \frac{3\pi}{11} \right) ), (b) (-\tan \left( \frac{3\pi}{11} \right) ), (c) ( \tan \left( \frac{5\pi}{22} \right) ), (d) (-\tan \left( \frac{5\pi}{22} \right) )</td>
</tr>
<tr>
<td>141.</td>
<td>( \cos \left( \frac{19\pi}{11} \right) = ? )</td>
<td>(a) ( \cos \left( \frac{2\pi}{11} \right) ), (b) (-\cos \left( \frac{2\pi}{11} \right) ), (c) ( \cos \left( \frac{7\pi}{22} \right) ), (d) (-\cos \left( \frac{7\pi}{22} \right) )</td>
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<tr>
<td>142.</td>
<td>( \tan \left( \frac{9\pi}{11} \right) = ? )</td>
<td>(a) ( \tan \left( \frac{7\pi}{22} \right) ), (b) (-\tan \left( \frac{7\pi}{22} \right) ), (c) ( \tan \left( \frac{2\pi}{11} \right) ), (d) (-\tan \left( \frac{2\pi}{11} \right) )</td>
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<tr>
<td>143.</td>
<td>( \cos \left( \frac{-4\pi}{11} \right) = ? )</td>
<td>(a) ( \cos \left( \frac{4\pi}{11} \right) ), (b) (-\cos \left( \frac{4\pi}{11} \right) ), (c) ( \cos \left( \frac{3\pi}{22} \right) ), (d) (-\cos \left( \frac{3\pi}{22} \right) )</td>
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<tr>
<td>144.</td>
<td>( \sin \left( \frac{5\pi}{7} \right) = ? )</td>
<td>(a) ( \sin \left( \frac{2\pi}{7} \right) ), (b) (-\sin \left( \frac{2\pi}{7} \right) ), (c) ( \sin \left( \frac{3\pi}{14} \right) ), (d) (-\sin \left( \frac{3\pi}{14} \right) )</td>
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<tr>
<td>145.</td>
<td>( \sin \left( \frac{6\pi}{5} \right) = ? )</td>
<td>(a) ( \sin \left( \frac{\pi}{5} \right) ), (b) (-\sin \left( \frac{\pi}{5} \right) ), (c) ( \sin \left( \frac{3\pi}{10} \right) ), (d) (-\sin \left( \frac{3\pi}{10} \right) )</td>
</tr>
<tr>
<td>146.</td>
<td>( \tan \left( \frac{-2\pi}{5} \right) = ? )</td>
<td>(a) ( \tan \left( \frac{2\pi}{5} \right) ), (b) (-\tan \left( \frac{2\pi}{5} \right) ), (c) ( \tan \left( \frac{\pi}{10} \right) ), (d) (-\tan \left( \frac{\pi}{10} \right) )</td>
</tr>
<tr>
<td>147.</td>
<td>( \tan \left( \frac{20\pi}{11} \right) = ? )</td>
<td>(a) ( \tan \left( \frac{2\pi}{11} \right) ), (b) (-\tan \left( \frac{2\pi}{11} \right) ), (c) ( \tan \left( \frac{7\pi}{22} \right) ), (d) (-\tan \left( \frac{7\pi}{22} \right) )</td>
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<tr>
<td>148.</td>
<td>( \tan \left( \frac{-2\pi}{11} \right) = ? )</td>
<td>(a) ( \tan \left( \frac{2\pi}{11} \right) ), (b) (-\tan \left( \frac{2\pi}{11} \right) ), (c) ( \tan \left( \frac{7\pi}{22} \right) ), (d) (-\tan \left( \frac{7\pi}{22} \right) )</td>
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</table>

149. Suppose \( \theta \), measured in degrees, is in quadrant II. Then \( \sin \theta = ? \)
(a) \( \sin(180^\circ - \theta) \), (b) \(-\sin(180^\circ - \theta) \), (c) \( \sin(\theta - 180^\circ) \), (d) \( \sin(360^\circ - \theta) \)

150. Suppose \( \theta \), measured in degrees, is in quadrant IV. Then \( \tan \theta = ? \)
(a) \(-\tan(\theta + 180^\circ) \), (b) \(-\tan(\theta - 180^\circ) \), (c) \( \tan(540^\circ - \theta) \), (d) \(-\tan(360^\circ - \theta) \)

151. Suppose \( \theta \), measured in degrees, is in quadrant III. Then \( \cos \theta = ? \)
(a) \( \cos(180^\circ - \theta) \), (b) \(-\cos(\theta - 180^\circ) \), (c) \( \cos(180^\circ + \theta) \), (d) \(-\cos(360^\circ - \theta) \)
153. Suppose $\theta$, measured in degrees, is in quadrant IV. Then $\sin \theta = ?$
(a) $-\sin(360^\circ - \theta)$  
(b) $\sin(\theta - 180^\circ)$  
(c) $\sin(180^\circ + \theta)$  
(d) $-\sin(360^\circ + \theta)$

154. Suppose $\theta$, measured in degrees, is in quadrant II. Then $\tan \theta = ?$
(a) $-\tan(180^\circ + \theta)$  
(b) $-\tan(180^\circ - \theta)$  
(c) $-\tan(\theta - 180^\circ)$  
(d) $\tan(360^\circ - \theta)$

155. Suppose $\theta$, measured in degrees, is in quadrant III. Then $\sin \theta = ?$
(a) $\sin(\theta - 180^\circ)$  
(b) $-\sin(360^\circ + \theta)$  
(c) $\sin(360^\circ - \theta)$  
(d) $-\sin(\theta - 180^\circ)$

156. Suppose $\theta$, measured in degrees, is in quadrant II. Then $\cos \theta = ?$
(a) $\cos(180^\circ + \theta)$  
(b) $-\cos(180^\circ - \theta)$  
(c) $\cos(\theta - 180^\circ)$  
(d) $-\cos(360^\circ - \theta)$

157. Suppose $\theta$, measured in degrees, is in quadrant III. Then $\tan \theta = ?$
(a) $\tan(\theta - 180^\circ)$  
(b) $-\tan(360^\circ + \theta)$  
(c) $\tan(360^\circ - \theta)$  
(d) $\tan(180^\circ - \theta)$

158. Suppose $\theta$, measured in degrees, is in quadrant IV. Then $\cos \theta = ?$
(a) $\cos(\theta - 180^\circ)$  
(b) $-\cos(360^\circ + \theta)$  
(c) $\cos(180^\circ - \theta)$  
(d) $\cos(360^\circ - \theta)$
159. What function does the graph below show? \( x \) is in radians.
(a) \( y = \sin x \)  
(b) \( y = \cos x \)  
(c) \( y = \tan x \)  
(b) \( y = \cot x \)  
(e) \( y = \sec x \)  
(f) \( y = \csc x \)
161. What function does the graph below show? \( x \) is in radians.
(a) \( y = \sin x \)  
(b) \( y = \cos x \)  
(c) \( y = \tan x \)  
(b) \( y = \cot x \)  
(e) \( y = \sec x \)  
(f) \( y = \csc x \)

162. What function does the graph below show? \( x \) is in degrees.
(a) \( y = \sin x \)  
(b) \( y = \cos x \)  
(c) \( y = \tan x \)  
(b) \( y = \cot x \)  
(e) \( y = \sec x \)  
(f) \( y = \csc x \)
163. What function does the graph below show? $x$ is in degrees.
(a) $y = \sin x$  
(b) $y = \cos x$  
(c) $y = \tan x$  
(b) $y = \cot x$  
(e) $y = \sec x$  
(f) $y = \csc x$

![Graph of trigonometric functions](image1)

164. What function does the graph below show? $x$ is in degrees.
(a) $y = \sin x$  
(b) $y = \cos x$  
(c) $y = \tan x$  
(b) $y = \cot x$  
(e) $y = \sec x$  
(f) $y = \csc x$

![Graph of trigonometric functions](image2)
165. What function does the graph below show? \( x \) is in degrees.
(a) \( y = \sin(2x) \)  (b) \( y = 2 \sin x \)  (c) \( y = \sin(x + 2) \)  (d) \( y = \sin(x) + 2 \)
(e) \( y = \sin(x/2) \)  (f) \( y = \frac{1}{2} \sin x \)  (g) \( y = \sin(x - 2) \)  (h) \( y = \sin(x) - 2 \)

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(f) $y = \frac{1}{2} \sin x$  
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(d) $y = \sin(x) + 2$
(e) $y = \sin(x/2)$  
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(e) \( y = \sin(x/2) \)  
(f) \( y = \frac{1}{2} \sin x \)  
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170. What function does the graph below show? \( x \) is in radians.
(a) \( y = \sin(2x) \)  
(b) \( y = 2 \sin x \)  
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(d) \( y = \sin(x) + 2 \)  
(e) \( y = \sin(x/2) \)  
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(a) \( y = \sin(2x) \)  
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(c) \( y = \sin(x + 2) \)  
(d) \( y = \sin(x) + 2 \)  
(e) \( y = \sin(x/2) \)  
(f) \( y = \frac{1}{2} \sin x \)  
(g) \( y = \sin(x - 2) \)  
(h) \( y = \sin(x) - 2 \)
173. What function does the graph below show? $x$ is in degrees.
(a) $y = 3 \sin(x) + 2$  
(b) $y = \sin(2x) + 4$  
(c) $y = 5 \sin(x) - 1$
(d) $y = \sin(x - 2) + 4$  
(e) $y = 5 \sin(x - 2)$  
(f) $y = \sin(x + 70) + 4$

174. What function does the graph below show? $x$ is in radians.
(a) $y = \sin(5x) + 4$  
(b) $y = 5 \sin(2x)$  
(c) $y = \sin(5x/2) + 4$
(d) $y = 10 \sin(x/2)$  
(e) $y = \sin(10x - \pi)$  
(f) $y = 5 \sin(x - \pi)$
175. What function does the graph below show? \( x \) is in radians.
(a) \( y = \sin(x - 1) + 3 \)  
(b) \( y = 4 \sin(x - 2) \)  
(c) \( y = 2 \sin(x + 1) \)  
(d) \( y = \sin(2x + 1) \)  
(e) \( y = 2 \sin(x) + 1 \)  
(f) \( y = \sin(2x) + 2 \)

176. What function does the graph below show? \( x \) is in degrees.
(a) \( y = 3 \sin(x/2) - 1 \)  
(b) \( y = 2 \sin(x/2 - 60) \)  
(c) \( y = 3 \sin(x + 120) + 1 \)  
(d) \( y = \sin(2x - 120) + 2 \)  
(e) \( y = 2 \sin(x - 60) + 1 \)  
(f) \( y = \sin(x/2 + 120) + 1 \)
177. What is the amplitude of the function: \( y = 4 \sin (5x + 2) \)? Angles are in radians.

178. What is the period of the function: \( y = 3 \sin (2x) + 6 \)? Angles are in radians.

179. What is the vertical translation of the function: \( y = 2 \sin(3x + 1) - 5 \), compared to the function \( y = \sin x \)? Angles are in radians.

180. What is the horizontal translation of the function: \( y = \sin(4x + 3) + 1 \), compared to the function \( y = \sin x \)? Angles are in radians.

181. What is the amplitude of the function: \( y = 2 \cos (x/2) - 1 \)? Angles are in degrees.

182. What is the period of the function: \( y = \cos (4x - 60) + 2 \)? Angles are in degrees.

183. What is the vertical translation of the function: \( y = 5 \cos (2x + 30) \), compared to the function \( y = \cos x \)? Angles are in degrees.

184. What is the horizontal translation of the function: \( y = 3 \cos (x - 15) + 4 \), compared to the function \( y = \cos x \)? Angles are in degrees.
Word problems

185. A bug is clinging to the spoke of a bicycle wheel as the bicycle is ridden down the road. The height $z$ of the bug in inches above the ground as a function of the time $t$ in seconds is: $z = 8\sin\left(\frac{\pi t}{3}\right) + 14$, where angles are measured in radians. How long does it take the wheel (and the bug) to make one complete turn?
(a) 8 sec (b) 3 sec (c) 14 sec (d) 4 sec (e) 6 sec (f) 7 sec

186. In Problem 185, how far is the bug from the center of the wheel?
(a) 3 in (b) 8 in (c) 14 in (d) 28 in (e) 16 in (f) 7 in

187. In Problem 185, what is the diameter of the wheel?
(a) 14 in (b) 8 in (c) 24 in (d) 28 in (e) 16 in (f) 21 in

188. A boat is bobbing up and down on the waves. The depth of water $z$ in meters below the boat as a function of time $t$ in seconds is: $z = 1.2\sin(bt) + 5.1$, where angles are measured in degrees. If two consecutive high points are separated by 6 sec, what is $b$?
(a) 6 (b) $\frac{1}{30}$ (c) $\frac{1}{60}$ (d) $\frac{1}{6}$ (e) 30 (f) 60

189. In Problem 188, what is the difference between the greatest and the smallest value of $z$?
(a) 3.9 m (b) 5.1 m (c) 1.2 m (d) 7.8 m (e) 10.2 m (f) 2.4 m

190. In Problem 188, how deep would the water be if there were no waves on it?
(a) 3.9 m (b) 5.1 m (c) 1.2 m (d) 7.8 m (e) 10.2 m (f) 2.4 m

191. You are riding on a Ferris wheel. Your height $z$ in meters above the ground as a function of the time $t$ in seconds since the wheel started turning is: $z = 15\sin(24t + c) + 16$, where angles are measured in degrees. What is the diameter of the wheel?
(a) 24 m (b) 15 m (c) 16 m (d) 12 m (e) 30 m (f) 32 m

192. In Problem 191, how high are you when you’re at the top of the wheel?
(a) 47 m (b) 31 m (c) 32 m (d) 33 m (e) 46 m (f) 14 m

193. In Problem 191, how long does it take for the wheel to make one complete turn?
(a) 15 sec (b) 24 sec (c) 48 sec (d) 7.5 sec (e) 12 sec (f) 30 sec
194. In Problem 191, you are at the bottom of the wheel at time $t = 0$. What is the value of $c$?
(a) 7.5  (b) 90  (c) 24
(d) -7.5  (e) -90  (f) -24

195. The President-for-life of Annexia was born on August 15. In commemoration of this event, he has decreed that the Annexian electrical system should produce alternating current with a frequency of 15 cycles per second and an amplitude of 8 volts. Which equation describes voltage $V$ as a function of time in seconds $t$? Angles are measured in radians.
(a) $V = 8\sin(15\pi t)$  (b) $V = 8\sin(2\pi t - 15)$  (c) $V = 4\sin(15\pi t) + 4$
(d) $V = 8\sin(30\pi t)$  (e) $V = 4\sin\left(\frac{\pi t}{15}\right) + 4$  (f) $V = 15\sin(8\pi t)$

196. After an earthquake, the water in a lake sloshes back and forth with a period of 40 min. At a point on the shore, the water oscillates from 2 ft above to 2 ft below its normal level. At the time of the quake, the water at that point is at normal level, and it initially rises after the quake. Which equation gives the water level $z$, relative to normal level, as a function of the time $t$ in minutes after the earthquake? Angles are measured in radians.
(a) $z = 2\sin\left(\frac{\pi t}{40}\right)$  (b) $z = 4\sin(40\pi t)$  (c) $z = 2\sin(40\pi t)$
(d) $z = 2\sin\left(\frac{\pi t}{20}\right)$  (e) $z = 4\sin(20\pi t)$  (f) $z = 4\sin\left(\frac{\pi t}{20}\right)$

197. The population of blue-tongued voles varies sinusoidally with a period of 18 years, between a minimum of 300 voles and a maximum of 1100. The population was at its highest level in 1900, when observation began. Which equation describes the population $P$ of voles as a function of the time $t$ in years since 1900? Angles are measured in radians.
(a) $P = 800\sin\left(\frac{\pi t}{18} - \frac{\pi}{2}\right) + 300$  (b) $P = 400\sin\left(\frac{\pi t}{36} - \frac{\pi}{2}\right) + 300$
(c) $P = 1100\sin\left(\frac{\pi t}{18}\right) - 300$  (d) $P = 400\sin\left(\frac{\pi t}{9} + \frac{\pi}{2}\right) + 700$
(e) $P = 800\sin\left(18\pi t - \frac{\pi}{2}\right) + 300$  (f) $P = 400\sin\left(18\pi t - \frac{\pi}{2}\right) + 700$
198. The forecast water use in a city varies sinusoidally with a period of 365 days. The lowest use occurs on December 31, when 120 acre-feet are used; the highest use is 220 acre-feet. Which equation gives the water use \( w \) as a function of time \( t \) in days after December 31? Angles are in radians.

(a) \( w = 120 \sin \left( \frac{t}{365} \right) + 100 \)  
(b) \( w = 120 \sin \left( 365t + \frac{\pi}{2} \right) + 100 \)

(c) \( w = 50 \sin \left( \frac{2\pi t}{365} - \frac{\pi}{2} \right) + 170 \)  
(d) \( w = 100 \sin \left( 730\pi t \right) + 120 \)

(e) \( w = 50 \sin \left( \frac{t}{365} - \frac{\pi}{2} \right) + 120 \)  
(f) \( w = 100 \sin \left( \frac{365t}{\pi} + \frac{2}{\pi} \right) + 170 \)

199. A buoy in a harbor rises and falls with the tide. The difference between high and low tide is 8 ft. Two consecutive high tides are separated by 12 hours. At low tide, the buoy is 19 ft above the bottom of the harbor. If the tide is high at midnight, which equation gives the elevation \( z \) of the buoy above the harbor bottom as a function of the time \( t \) in hours after midnight? Angles are measured in degrees.

(a) \( z = 19 \sin(12t - 12) + 8 \)  
(b) \( z = 8 \sin(12t - 12) + 19 \)

(c) \( z = 8 \sin \left( \frac{t}{12} + 6 \right) + 19 \)  
(d) \( z = 4 \sin(12t - 6) + 19 \)

(e) \( z = 27 \sin \left( \frac{t}{12} + 30 \right) + 8 \)  
(f) \( z = 4 \sin(30t + 90) + 23 \)

200. The icecaps on the planet Tralfamadore vary sinusoidally in extent, driven by the 37-year cycle of the planet’s star. The maximum extent, which occurred in 1959, is 900,000 km\(^2\). The minimum is 100,000 km\(^2\). Which equation gives the area \( A \) of the icecap, in 1000 km\(^2\), as a function of the time \( t \) in years since 1959? Angles are measured in radians.

(a) \( A = 400 \sin \left( \frac{37\pi t}{2} - \frac{\pi}{2} \right) + 100 \)  
(b) \( A = 900 \sin \left( \frac{\pi t}{37} + 1959 \right) + 100 \)

(c) \( A = 400 \sin \left( \frac{2\pi t}{37} + \frac{\pi}{2} \right) + 500 \)  
(d) \( A = 800 \sin \left( \frac{\pi t}{37} - \pi \right) + 100 \)

(e) \( A = 800 \sin \left( \frac{\pi t}{37} - 1959 \right) + 100 \)  
(f) \( A = 400 \sin \left( \frac{2\pi t}{37} - \frac{\pi}{2} \right) + 500 \)
Unit circle problems

In problems 201-210, give exact values. Rationalize all denominators. Do not use a calculator.

201. The point \((x, y)\) lies on the unit circle at \(\theta = 30^\circ\). Find the values of \(x\) and \(y\).

202. The point \((x, y)\) lies on the unit circle at \(\theta = 45^\circ\). Find the values of \(x\) and \(y\).

203. The point \((x, y)\) lies on the unit circle at \(\theta = 120^\circ\). Find the values of \(x\) and \(y\).

204. The point \((x, y)\) lies on the unit circle at \(\theta = 225^\circ\). Find the values of \(x\) and \(y\).

205. The point \((x, y)\) lies on the unit circle at \(\theta = 270^\circ\). Find the values of \(x\) and \(y\).

206. The point \((x, y)\) lies on the unit circle at \(\theta = \pi/3\) radians. Find the values of \(x\) and \(y\).

207. The point \((x, y)\) lies on the unit circle at \(\theta = 3\pi/4\) radians. Find the values of \(x\) and \(y\).

208. The point \((x, y)\) lies on the unit circle at \(\theta = 7\pi/6\) radians. Find the values of \(x\) and \(y\).

209. The point \((x, y)\) lies on the unit circle at \(\theta = 3\pi/2\) radians. Find the values of \(x\) and \(y\).

210. The point \((x, y)\) lies on the unit circle at \(\theta = 5\pi/3\) radians. Find the values of \(x\) and \(y\).

In problems 211-225, use a calculator or equivalent to find the values. Round your answers to four decimal places.

211. The point \((x, y)\) lies on the unit circle at \(\theta = 41^\circ\). Find the values of \(x\) and \(y\).

212. The point \((x, y)\) lies on the unit circle at \(\theta = 79^\circ\). Find the values of \(x\) and \(y\).

213. The point \((x, y)\) lies on the unit circle at \(\theta = 155^\circ\). Find the values of \(x\) and \(y\).

214. The point \((x, y)\) lies on the unit circle at \(\theta = 198^\circ\). Find the values of \(x\) and \(y\).

215. The point \((x, y)\) lies on the unit circle at \(\theta = 311^\circ\). Find the values of \(x\) and \(y\).

216. The point \((x, y)\) lies on the unit circle at \(\theta = 0.3\) radians. Find the values of \(x\) and \(y\).

217. The point \((x, y)\) lies on the unit circle at \(\theta = 1.9\) radians. Find the values of \(x\) and \(y\).
218. The point \((x, y)\) lies on the unit circle at \(\theta = 3.75\) radians. Find the values of \(x\) and \(y\).

219. The point \((x, y)\) lies on the unit circle at \(\theta = 5.1\) radians. Find the values of \(x\) and \(y\).

220. The point \((x, y)\) lies on the unit circle at \(\theta = 23\) radians. Find the values of \(x\) and \(y\).

221. The point \((x, y)\) lies on the unit circle at \(\theta = \pi/5\) radians. Find the values of \(x\) and \(y\).

222. The point \((x, y)\) lies on the unit circle at \(\theta = 5\pi/7\) radians. Find the values of \(x\) and \(y\).

223. The point \((x, y)\) lies on the unit circle at \(\theta = 17\pi/13\) radians. Find the values of \(x\) and \(y\).

224. The point \((x, y)\) lies on the unit circle at \(\theta = 19\pi/23\) radians. Find the values of \(x\) and \(y\).

225. The point \((x, y)\) lies on the unit circle at \(\theta = 5.6\pi\) radians. Find the values of \(x\) and \(y\).