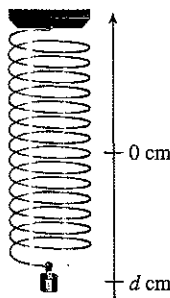29. Vibrating Spring A mass on a spring oscillates back and forth and completes one cycle in 0.5 sec. Its maximum displacement is 3 cm. Write an equation that models this motion.

30. Tuning Fork A point on the tip of a tuning fork vibrates in harmonic motion described by the equation $d = 14 \sin \omega t$. Find ω for a tuning fork that has a frequency of 528 vibrations per second.

31. Ferris Wheel Motion The Ferris wheel shown in this figure makes one complete turn every 20 sec. A rider's height, h, above the ground can be modeled by the equation $h = a \sin \omega t + k$, where h and k are given in feet and t is given in seconds.
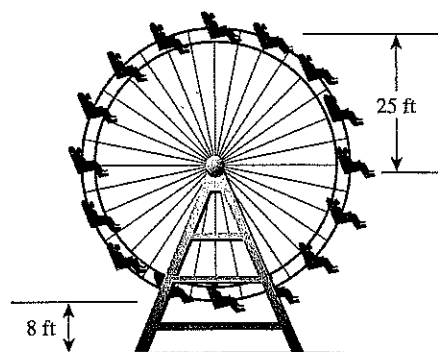
(a) What is the value of a?

(b) What is the value of k?

(c) What is the value of ω?

32. Ferris Wheel Motion Jacob and Emily ride a Ferris wheel at a carnival in Billings, Montana. The wheel has a 16-m diameter and turns at 3 rpm with its lowest point 1 m above the ground. Assume that Jacob and Emily's height h above the ground is a sinusoidal function of time t (in seconds), where $t = 0$ represents the lowest point of the wheel.

(a) Write an equation for h.

(b) Draw a graph of h for $0 \le t \le 30$.

(c) Use h to estimate Jacob and Emily's height above the ground at $t = 4$ and $t = 10$.

33. Monthly Temperatures in Charleston The monthly normal mean temperatures for the last 30 years in Charleston, SC, are shown in Table 4.3. A scatter plot suggests that the mean monthly temperatures follow a sinusoidal curve over time. Assume that the sinusoid has equation $y = a \sin (b (t - h)) + k$.

(a) Given that the period is 12 months, find b.

(b) Assuming that the high and low temperatures in the table determine the range of the sinusoid, find a and k.

(c) Find a value of h that will put the minimum at $t = 1$ and the maximum at $t = 7$.

(d) Superimpose a graph of your sinusoid on a scatter plot of the data. How good is the fit?

(e) Use your sinusoidal model to predict dates in the year when the mean temperature in Charleston will be 70°. (Assume that $t = 0$ represents January 1.)

Table 4.3 Temperature Data for Charleston, SC

Month	Temperature
1	48
2	51
3	58
4	64
5	72
6	78
7	82
8	81
9	76
10	66
11	58
12	51

Source: National Climatic Data Center, as reported in the World Almanac and Book of Facts 2009.
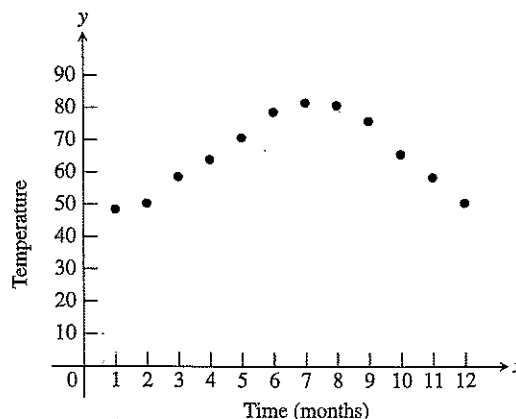
34. Writing to Learn For the Ferris wheel in Exercise 31, which equation correctly models the height of a rider who begins the ride at the bottom of the wheel when $t = 0$?

(a) $h = 25 \sin \dfrac{\pi t}{10}$

(b) $h = 25 \sin \dfrac{\pi t}{10} + 8$

(c) $h = 25 \sin \dfrac{\pi t}{10} + 33$

(d) $h = 25 \sin \left(\dfrac{\pi t}{10} + \dfrac{3\pi}{2} \right) + 33$

Explain your thought process, and use of a graphing utility in choosing the correct modeling equation.

35. Monthly Sales   Owing to startup costs and seasonal variations, Gina found that the monthly profit in her bagel shop during the first year followed an up-and-down pattern that could be modeled by $P = 2t - 7 \sin(\pi t/3)$, where P was measured in hundreds of dollars and t was measured in months after January 1.

(a) In what month did the shop first begin to make money?

(b) In what month did the shop enjoy its greatest profit in that first year?

36. Weight Loss   Courtney tried several different diets over a two-year period in an attempt to lose weight. She found that her weight W followed a fluctuating curve that could be modeled by the function $W = 220 - 1.5t + 9.81 \sin(\pi t/4)$, where t was measured in months after January 1 of the first year and W was measured in pounds.

(a) What was Courtney's weight at the start and at the end of two years?

(b) What was her maximum weight during the two-year period?

(c) What was her minimum weight during the two-year period?

Standardized Test Questions

37. True or False   Higher frequency sound waves have shorter periods. Justify your answer.

38. True or False   A car traveling at 30 miles per hour is traveling faster than a ship traveling at 30 knots. Justify your answer.

You may use a graphing calculator when answering these questions.

39. Multiple Choice   To get a rough idea of the height of a building, John paces off 50 feet from the base of the building, then measures the angle of elevation from the ground to the top of the building at that point to be 58°. About how tall is the building?

(A) 31 feet   (B) 42 feet   (C) 59 feet

(D) 80 feet   (E) 417 feet

40. Multiple Choice   A boat leaves harbor and travels at 20 knots on a bearing of 90°. After two hours, it changes course to a bearing of 150° and continues at the same speed for another hour.

After the entire 3-hour trip, how far is it from the harbor?

(A) 50 nautical miles   (B) 53 nautical miles

(C) 57 nautical miles   (D) 60 nautical miles

(E) 67 nautical miles

41. Multiple Choice   At high tide at 8:15 P.M., the water level on the side of a pier is 9 feet from the top. At low tide 6 hours and 12 minutes later, the water level is 13 feet from the top. At which of the following times in that interval is the water level 10 feet from the top of the pier?

(A) 9:15 P.M.   (B) 9:48 P.M.   (C) 9:52 P.M.

(D) 10:19 P.M.   (E) 11:21 P.M.

42. Multiple Choice   The loudness of a musical tone is determined by which characteristic of its sound wave?

(A) Amplitude   (B) Frequency   (C) Period

(D) Phase shift   (E) Pitch

Explorations

43. Group Activity   The data for displacement versus time on a tuning fork, shown in Table 4.4, were collected using a CBL and a microphone.

Table 4.4   Tuning Fork Data

Time	Displacement	Time	Displacement
0.00091	−0.080	0.00362	0.217
0.00108	0.200	0.00379	0.480
0.00125	0.480	0.00398	0.681
0.00144	0.693	0.00416	0.810
0.00162	0.816	0.00435	0.827
0.00180	0.844	0.00453	0.749
0.00198	0.771	0:00471	0.581
0.00216	0.603	0.00489	0.346
0.00234	0.368	0.00507	0.077
0.00253	0.099	0.00525	−0.164
0.00271	−0.141	0.00543	−0.320
0.00289	−0.309	0.00562	−0.354
0.00307	−0.348	0.00579	−0.248
0.00325	−0.248	0.00598	−0.035
0.00344	−0.041		

(a) Graph a scatter plot of the data in the $[0, 0.0062]$ by $[-0.5, 1]$ viewing window.

(b) Select the equation that appears to be the best fit of these data.

i. $y = 0.6 \sin(2464x - 2.84) + 0.25$

ii. $y = 0.6 \sin(1210x - 2) + 0.25$

iii. $y = 0.6 \sin(2440x - 2.1) + 0.15$

(c) What is the approximate frequency of the tuning fork?

44. Writing to Learn   Human sleep-awake cycles at three different ages are described by the accompanying graphs. The portions of the graphs above the horizontal lines represent times awake, and the portions below represent times asleep.

Newborn

Four years

Adult