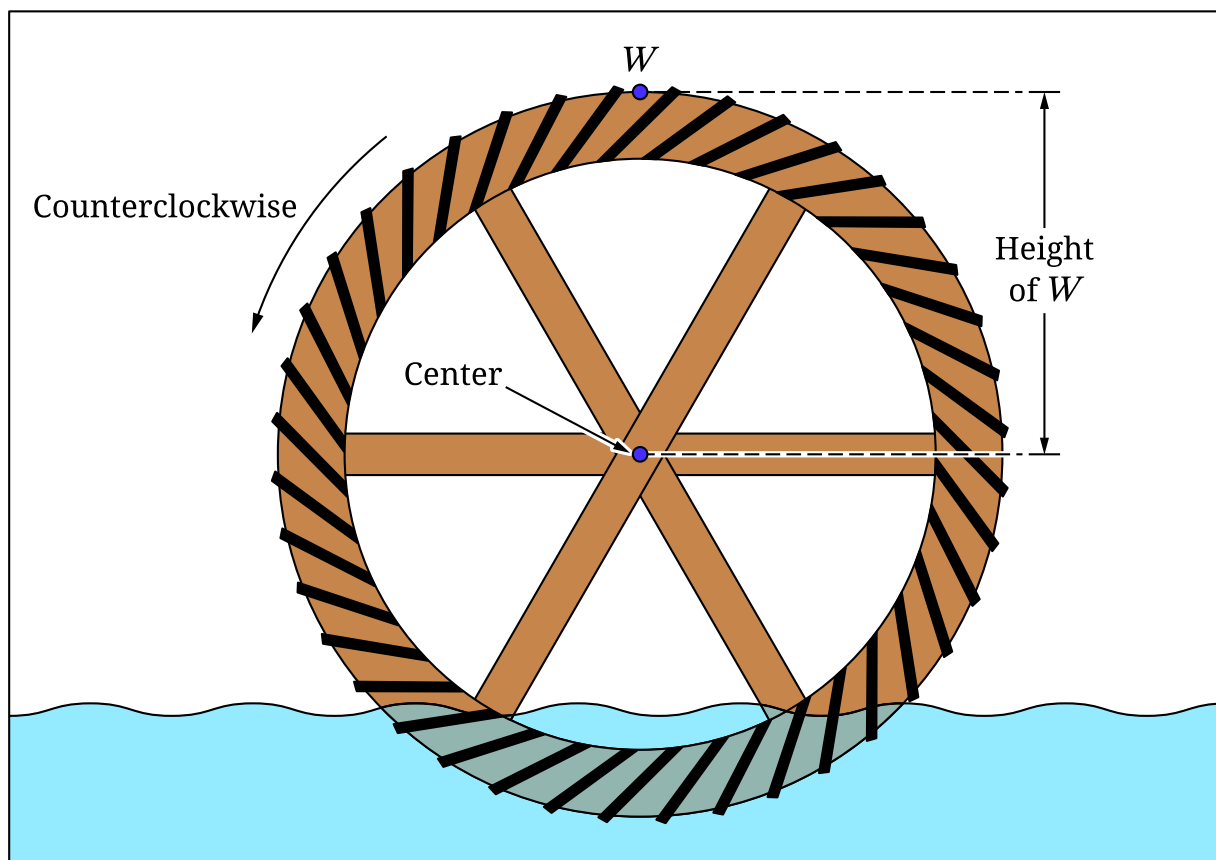


3. The figure shows a circular waterwheel that rotates in a counterclockwise direction at a constant rate and completes 1 revolution in 10 seconds. At time $t = 0$, point W on the edge of the waterwheel is at a height of 6 feet directly above the center of the waterwheel. The height of point W from the horizontal line through the center of the waterwheel periodically decreases and increases as the waterwheel moves.

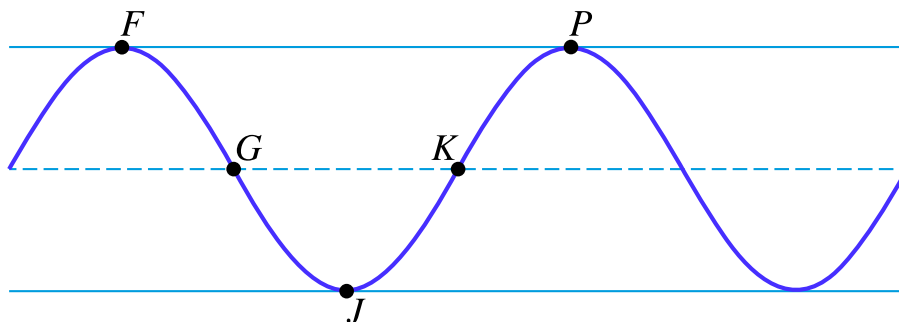


Note: Figure not drawn to scale.

The sinusoidal function h models the height of point W from the horizontal line through the center of the waterwheel, in feet, as a function of time t , in seconds. A positive value of $h(t)$ indicates W is above the line through the center; a negative value of $h(t)$ indicates W is below the line through the center.

- A.** The graph of h and its dashed midline for two full cycles is shown. Five points, F , G , J , K , and P , are labeled on the graph. No scale is indicated, and no axes are presented.

Determine possible coordinates $(t, h(t))$ for the five points: F , G , J , K , and P .



- B.** The function h can be written in the form $h(t) = a \sin(b(t + c)) + d$. Find values of constants a , b , c , and d .
- C.** Refer to the graph of h in part A. The t -coordinate of J is t_1 , and the t -coordinate of K is t_2 .
- On the interval (t_1, t_2) , which of the following is true about h ?
 - h is positive and increasing.
 - h is positive and decreasing.
 - h is negative and increasing.
 - h is negative and decreasing.
 - On the interval (t_1, t_2) , describe the concavity of the graph of h and determine whether the rate of change of h is increasing or decreasing.

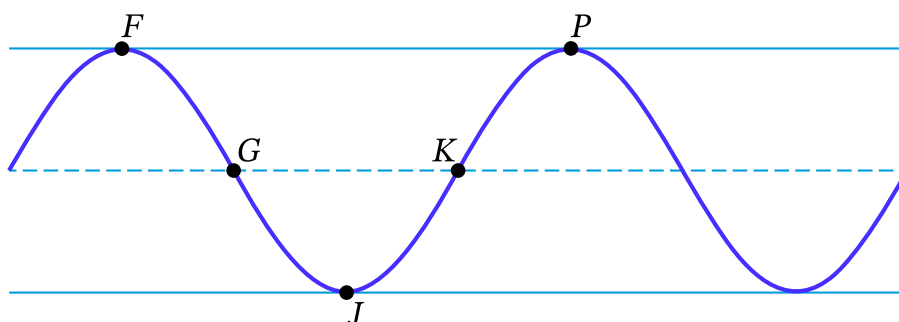
3. For a guitar to make a sound, the strings need to vibrate, or move up and down or back and forth, in a motion that can be modeled by a periodic function.

At time $t = 0$ seconds, point X on one vibrating guitar string starts at its highest position, 2 millimeters above its resting position. Then it passes through its resting position and moves to its lowest position, 2 millimeters below the resting position. Point X then passes through its resting position and returns to 2 millimeters above the resting position. This motion occurs 200 times in 1 second.

The sinusoidal function h models how far point X is from its resting position, in millimeters, as a function of time t , in seconds. A positive value of $h(t)$ indicates the point is above the resting position; a negative value of $h(t)$ indicates the point is below the resting position.

- A. The graph of h and its dashed midline for two full cycles is shown. Five points, F , G , J , K , and P , are labeled on the graph. No scale is indicated, and no axes are presented.

Determine possible coordinates $(t, h(t))$ for the five points: F , G , J , K , and P .



- B. The function h can be written in the form $h(t) = a \sin(b(t + c)) + d$. Find values of constants a , b , c , and d .
- C. Refer to the graph of h in part A. The t -coordinate of G is t_1 , and the t -coordinate of J is t_2 .
- On the interval (t_1, t_2) , which of the following is true about h ?
 - h is positive and increasing.
 - h is positive and decreasing.
 - h is negative and increasing.
 - h is negative and decreasing.
 - On the interval (t_1, t_2) , describe the concavity of the graph of h and determine whether the rate of change of h is increasing or decreasing.



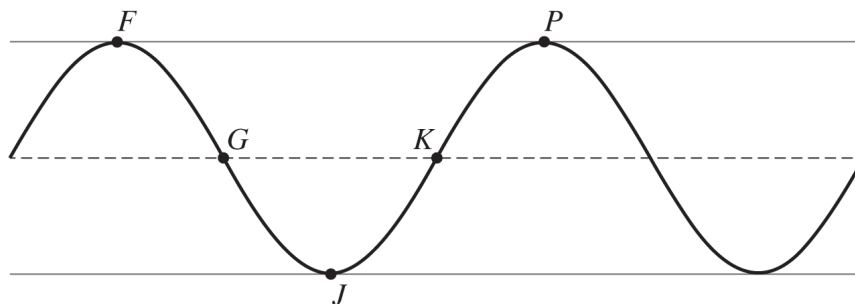
Note: Figure not drawn to scale.

3. The tire of a car has a radius of 9 inches, and a person rolls the tire forward at a constant rate on level ground, as shown in the figure. Point W on the edge of the tire touches the ground at time $t = \frac{1}{2}$ second. The tire completes a full rotation, and the next time W touches the ground is at time $t = \frac{5}{2}$ seconds. The maximum height of W above the ground is 18 inches. As the tire rolls, the height of W above the ground periodically increases and decreases.

The sinusoidal function h models the height of point W above the ground, in inches, as a function of time t , in seconds.

- (A) The graph of h and its dashed midline for two full cycles is shown. Five points, F , G , J , K , and P , are labeled on the graph. No scale is indicated, and no axes are presented.

Determine possible coordinates $(t, h(t))$ for the five points: F , G , J , K , and P .



- (B) The function h can be written in the form $h(t) = a \sin(b(t + c)) + d$. Find values of constants a , b , c , and d .

(C) Refer to the graph of h in part (A). The t -coordinate of K is t_1 , and the t -coordinate of P is t_2 .

(i) On the interval (t_1, t_2) , which of the following is true about h ?

- a. h is positive and increasing.
- b. h is positive and decreasing.
- c. h is negative and increasing.
- d. h is negative and decreasing.

(ii) Describe how the rate of change of h is changing on the interval (t_1, t_2) .

Write your responses to this question only on the designated pages in the separate Free Response booklet. Write your solution to each part in the space provided for that part.