

For  $0 \leq t \leq 12$ , a particle moves along the  $x$ -axis. The velocity of the particle at time  $t$  is given by  $v(t) = \cos\left(\frac{\pi}{6}t\right)$ . The particle is at position  $x = -2$  at time  $t = 0$ .

a. For  $0 \leq t \leq 12$ , when is the particle moving left?

b. Write, but do not evaluate, an integral expression that gives the total distance traveled by the particle from time  $t = 0$  to time  $t = 6$ .

c. Find the acceleration of the particle at time  $t$ . Is the speed of the particle increasing, decreasing, or neither at time  $t = 4$ ? Explain your reasoning.

d. Find the position of the particle at time  $t = 4$ .

On a certain workday, the rate, in tons per hour, at which unprocessed gravel arrives at a gravel processing plant is modeled by  $G(t) = 90 + 45 \cos \frac{t^2}{18}$ , where  $t$  is measured in hours and  $0 \leq t \leq 8$ . At the beginning of the workday ( $t = 0$ ), the plant has 500 tons of unprocessed gravel. During the hours of operation,  $0 \leq t \leq 8$ , the plant processes gravel at a constant rate of 100 tons per hour.

- a. Find  $G'(5)$ . Using correct units, interpret your answer in the context of the problem.
- b. Find the total amount of unprocessed gravel that arrives at the plant during the hours of operation on this workday.
- c. Is the amount of unprocessed gravel at the plant increasing or decreasing at time  $t = 5$  hours? Show the work that leads to your answer.
- d. What is the maximum amount of unprocessed gravel at the plant during the hours of operation on this workday? Justify your answer.

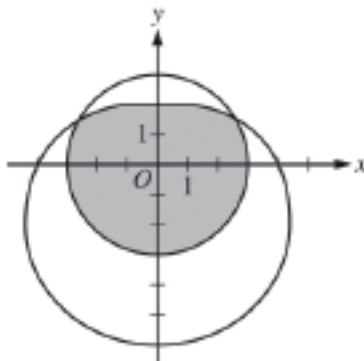
A particle moves along a straight line. For  $0 \leq t \leq 5$ , the velocity of the particle is given by  $v(t) = -2 + (t^2 + 3t)^{6/5} - t^3$ , and the position of the particle is given by  $s(t)$ . It is known that  $s(0) = 10$ .

a. Find all values of  $t$  in the interval  $2 \leq t \leq 4$  for which the speed of the particle is 2.

b. Write an expression involving an integral that gives the position  $s(t)$ . Use this expression to find the position of the particle at time  $t = 5$ .

c. Find all times  $t$  in the interval  $0 \leq t \leq 5$  at which the particle changes direction. Justify your answer.

d. Is the speed of the particle increasing or decreasing at time  $t = 4$ ? Give a reason for your answer.



The graphs of the polar curves  $r = 3$  and  $r = 4 - 2 \sin \theta$  are shown in the figure above. The curves intersect when  $\theta = \frac{\pi}{6}$  and  $\theta = \frac{5\pi}{6}$ .

- Let  $S$  be the shaded region that is inside the graph of  $r = 3$  and also inside the graph of  $r = 4 - 2 \sin \theta$ . Find the area of  $S$ .
- A particle moves along the polar curve  $r = 4 - 2 \sin \theta$  so that at time  $t$  seconds,  $\theta = t^2$ . Find the time  $t$  in the interval  $1 \leq t \leq 2$  for which the  $x$ -coordinate of the particle's position is  $-1$ .
- For the particle described in part (b), find the position vector in terms of  $t$ . Find the velocity vector at time  $t = 1.5$ .