1. The figure shows the graph of the velocity of a model rocket for the first 12 seconds after launch.

   a) Assuming the rocket was launched from ground level, about how high did it go?
   b) Assuming the rocket was launched from ground level, about how high was the rocket 12 seconds after launch?
   c) What is the rocket’s acceleration at \( t = 6 \) seconds? At \( t = 2 \) seconds?

2. The graph of a function \( f \) consists of a semicircle and two line segments as shown below.
   Let \( g(x) = \int_1^x f(t) \, dt \).
   a) Find \( g(1) \).
   b) Find \( g(3) \).
   c) Find \( g(-1) \).
   d) Find all the values of \( x \) on the open interval \((-3, 4)\) at which \( g \) has a relative maximum.
   e) Write an equation for the line tangent to the graph of \( g \) at \( x = -1 \).
   f) Find the \( x \)-coordinate of each point of inflection of the graph of \( g \) on the open interval \((-3, 4)\).
   g) Find the range of \( g \).

3. An automobile accelerates from rest at \( 1 + 3\sqrt{t} \) miles per hour per second for 9 seconds.
   a) What is its velocity after 9 seconds?
   b) How far does it travel in those 9 seconds?

4. Find the function \( f \) with derivative \( f'(x) = \sin x + \cos x \) whose graph passes through the point \((\pi, 3)\).

5. (1989BC). Let \( f \) be a function such that \( f''(x) = 6x + 8 \).
   a) Find \( f(x) \) if the graph of \( f \) is tangent to the line \( 3x - y = 2 \) at the point \((0, -2)\).
   b) Find the average value of \( f(x) \) on the closed interval \([-1, 1]\).
6. **(1999AB, Calculator).** A particle moves along the y-axis with velocity given by \( v(t) = t \sin(t^2) \) for \( t \geq 0 \).
   
   a) In which direction (up or down) is the particle moving at time \( t = 1.5 \)? Why?
   
   b) Find the acceleration of the particle at time \( t = 1.5 \). Is the velocity of the particle increasing at \( t = 1.5 \)?
   
   c) Given that \( y(t) \) is the position of the particle at time \( t \) and that \( y(0) = 3 \), find \( y(2) \).
   
   d) Find the total distance traveled by the particle from \( t = 0 \) and \( t = 2 \).

7. **(1990BC).** Let \( f \) and \( g \) be continuous functions with the following properties:
   
   i) \( g(x) = A - f(x) \) where \( A \) is a constant
   
   ii) \( \int_{1}^{3} f(x) \, dx = \int_{2}^{3} g(x) \, dx \)
   
   iii) \( \int_{2}^{3} f(x) \, dx = -3A \)

   a) Find \( \int_{1}^{3} f(x) \, dx \) in terms of \( A \).
   
   b) Find the average value of \( g(x) \) in terms of \( A \) over the interval \([1, 3]\).
   
   c) Find the value of \( k \) if \( \int_{0}^{1} f(x + 1) \, dx = kA \).

8. **(1994AB, Calculator).** Let \( F(x) = \int_{0}^{x} \sin(t^2) \, dt \) for \( 0 \leq x \leq 3 \).
   
   a) Use the trapezoidal rule with four equal subdivisions of the closed interval \([0, 1]\) to approximate \( F(1) \).
   
   b) On what interval is \( F \) increasing?
   
   c) If the average rate of change of \( F \) on the closed interval \([1, 3]\) is \( k \), find \( \int_{1}^{3} \sin(t^2) \, dt \) in terms of \( k \).

9. **(1991BC).** A particle moves on the x-axis so that its velocity at any time \( t \geq 0 \) is given by \( v(t) = 12t^2 - 36t + 15 \).
   
   a) Find the position \( x(t) \) of the particle at any time \( t \geq 0 \).
   
   b) Find all values of \( t \) for which the particle is at rest.
   
   c) Find the maximum velocity of the particle for \( 0 \leq t \leq 2 \).
   
   d) Find the total distance traveled by the particle from \( t = 0 \) to \( t = 2 \).
10. A particle moves along the $x$-axis. Its initial position at \( t = 0 \) sec is \( x(0) = 15 \). The graph below shows the particle's velocity \( v(t) \). The numbers are areas of the enclosed figures.

a) What is the particle's displacement between \( t = 0 \) and \( t = c \)?

b) What is the total distance traveled by the particle in the same time period?

c) Give the positions of the particle at times \( a, b, \) and \( c \).

d) Approximately where does the particle achieve its greatest positive acceleration on the interval \([0, b]\)? On \([0, c]\)?

11. (1999AB, Calculator). The rate at which water flows out of a pipe, in gallons per hour, is given by a differentiable function \( R \) of time \( t \). The table below shows the rate as measured every 3 hours for a 24-hour period.

<table>
<thead>
<tr>
<th>( t ) (hours)</th>
<th>0</th>
<th>3</th>
<th>6</th>
<th>9</th>
<th>12</th>
<th>15</th>
<th>18</th>
<th>21</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R(t) ) (gal/hr)</td>
<td>9.6</td>
<td>10.4</td>
<td>10.8</td>
<td>11.2</td>
<td>11.4</td>
<td>11.3</td>
<td>10.7</td>
<td>10.2</td>
<td>9.6</td>
</tr>
</tbody>
</table>

a) Use a midpoint Riemann sum with 4 subdivisions of equal length to approximate the value of \( \int_{0}^{24} R(t) \, dt \). Using correct units, explain the meaning of your answer in terms of water flow.

b) Is there some time \( t, 0 < t < 24 \), such that \( R'(t) = 0 \)? Justify your answer.

c) The rate of the water flow \( R(t) \) can be approximated by \( Q(t) = \frac{1}{30}(768 + 23t - t^2) \). Use \( Q(t) \) to approximate the average rate of water flow during the 24-hour time period. Indicate units of measure.