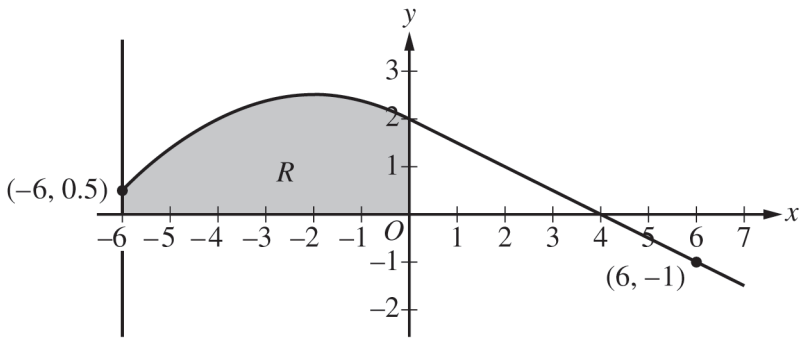


Graph of $f$

4. The graph of the differentiable function $f$, shown for $-6 \le x \le 7$, has a horizontal tangent at $x = -2$ and is linear for $0 \le x \le 7$. Let $R$ be the region in the second quadrant bounded by the graph of $f$, the vertical line $x = -6$, and the $x$- and $y$-axes. Region $R$ has area 12.

   (a) The function $g$ is defined by $g(x) = \int_0^x f(t)\,dt$. Find the values of $g(-6)$, $g(4)$, and $g(6)$.

   (b) For the function $g$ defined in part (a), find all values of $x$ in the interval $0 \le x \le 6$ at which the graph of $g$ has a critical point. Give a reason for your answer.

   (c) The function $h$ is defined by $h(x) = \int_{-6}^x f'(t)\,dt$. Find the values of $h(6)$, $h'(6)$, and $h''(6)$. Show the work that leads to your answers.

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**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.**





GO ON TO THE NEXT PAGE.

| $x$ | 0 | $\pi$ | $2\pi$ |
|---|---|---|---|
| $f'(x)$ | 5 | 6 | 0 |

5. The function $f$ is twice differentiable for all $x$ with $f(0) = 0$. Values of $f'$, the derivative of $f$, are given in the table for selected values of $x$.

   (a) For $x \geq 0$, the function $h$ is defined by $h(x) = \int_0^x \sqrt{1 + (f'(t))^2}\, dt$. Find the value of $h'(\pi)$. Show the work that leads to your answer.

   (b) What information does $\int_0^{\pi} \sqrt{1 + (f'(x))^2}\, dx$ provide about the graph of $f$ ?

   (c) Use Euler's method, starting at $x = 0$ with two steps of equal size, to approximate $f(2\pi)$. Show the computations that lead to your answer.

   (d) Find $\int (t + 5)\cos\left(\frac{t}{4}\right) dt$. Show the work that leads to your answer.

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**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.**





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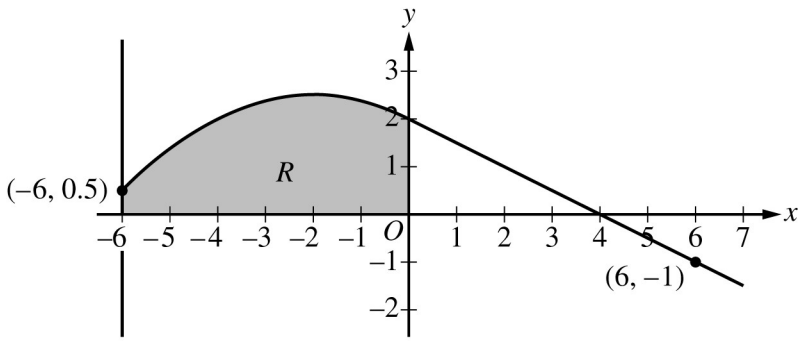
## Part B (AB or BC): Graphing calculator not allowed
## Question 4 — 9 points

**General Scoring Notes**
The model solution is presented using standard mathematical notation.

Answers (numeric or algebraic) need not be simplified. Answers given as a decimal approximation should be correct to three places after the decimal point. Within each individual free-response question, at most one point is not earned for inappropriate rounding.



Graph of $f$

The graph of the differentiable function $f$, shown for $-6 \le x \le 7$, has a horizontal tangent at $x = -2$ and is linear for $0 \le x \le 7$. Let $R$ be the region in the second quadrant bounded by the graph of $f$, the vertical line $x = -6$, and the $x$- and $y$-axes. Region $R$ has area 12.

| Model Solution | Scoring | |
|---|---|---|
| **(a)** The function $g$ is defined by $g(x) = \int_0^x f(t)\,dt$. Find the values of $g(-6)$, $g(4)$, and $g(6)$. | | |
| $g(-6) = \int_0^{-6} f(t)\,dt = -\int_{-6}^0 f(t)\,dt = -12$ | $g(-6)$ | **1 point** |
| $g(4) = \int_0^4 f(t)\,dt = \frac{1}{2}\cdot 4\cdot 2 = 4$ | $g(4)$ | **1 point** |
| $g(6) = \int_0^6 f(t)\,dt = \frac{1}{2}\cdot 4\cdot 2 - \frac{1}{2}\cdot 2\cdot 1 = 3$ | $g(6)$ | **1 point** |

**(c)** The function $h$ is defined by $h(x) = \int_{-6}^{x} f'(t)\,dt$. Find the values of $h(6)$, $h'(6)$, and $h''(6)$. Show the work that leads to your answers.

| | | |
|---|---|---|
| $h(6) = \int_{-6}^{6} f'(t)\,dt = f(6) - f(-6) = -1 - 0.5 = -1.5$ | Uses Fundamental Theorem of Calculus | **1 point** |
| | $h(6)$ with supporting work | **1 point** |
| $h'(x) = f'(x)$, so $h'(6) = f'(6) = -\frac{1}{2}$. | $h'(6)$ | **1 point** |
| $h''(x) = f''(x)$, so $h''(6) = f''(6) = 0$. | $h''(6)$ | **1 point** |

**Scoring notes:**

- Labeled values may be presented in any order.
- Unlabeled values are read from left to right and from top to bottom as $h(6)$, $h'(6)$, and $h''(6)$, respectively. A response that presents only 1 or 2 values must label them in order to earn any points.
- A response of $h(6) = -1.5$ does not earn either of the first 2 points. A response of $h(6) = f(6) - f(-6)$ earns the first point but not yet the second point.
- A response of $h(6) = -1 - 0.5$ is the minimum work required to earn both of the first 2 points.
- To earn the third point a response must state either $h'(x) = f'(x)$ or $h'(6) = f'(6)$, and provide an answer of $-\frac{1}{2}$.
- The fourth point is earned for a response of $h''(6) = 0$, with or without supporting work.
- A response that has one or more linkage errors does not earn the first point it would have otherwise earned. For example, $h'(x) = f'(6) = -\frac{1}{2}$ does not earn the third point but is eligible for the fourth point even in the presence of another linkage error, such as $h''(x) = f''(6) = 0$.

**Total for part (c) 4 points**

**Total for question 4 9 points**