1. Circle the letter of the following assertions which are always true.

(a) If \( f(x) \) is a function such that \( f(3) > 0 \) and \( f(7) < 0 \), then there exists \( 3 < c < 7 \) such that \( f(c) = 0 \).

(b) If \( f(x) \) is continuous at \( x = a \), then \( f(x) \) is differentiable at \( x = a \).

(c) If \( f''(5) = 0 \), then \( f(x) \) has an inflection point at \( x = 5 \).

(d) If \( f'(9) = 0 \) and \( f''(9) > 0 \), then \( f(x) \) has a local minimum at \( x = 9 \).

(e) If \( y \) is twice continuously differentiable, then \( D^2 y = (Dy)^2 \).

(f) If \( f(x) \) is continuous and even on \([-3, 3]\), then \( \int_{-3}^{3} f(x) \, dx = 0 \).

(g) If \( f(x) \) has a local maximum at \( x = 2 \), then \( f(x) \leq f(2) \) for all \( 0 \leq x \leq 4 \).

(h) If \( f(x) \) is differentiable on \([3, 6]\), \( f(3) = 2 \) and \( f(6) = 8 \), then there exists \( 3 < x < 6 \) such that \( f'(c) = 2 \).

(i) If \( f(x) \) is continuous on \([-4, 9]\), \( \int_{-4}^{9} f(t) \, dt = 5 \), and \( \int_{0}^{9} f(t) \, dt = 8 \), then \( \int_{0}^{-4} f(t) \, dt = 3 \).

(j) If \( f(x) \) is continuous on \([1, 3]\), and \( \int_{1}^{3} f(x) \, dx \) represents the area bounded by \( y = f(x) \), \( y = 0 \), \( x = 1 \) and \( x = 3 \), then \( f(x) \geq 0 \) on \([1, 3]\).
2. Consider \( L = \lim_{h \to 0} \frac{(\pi + h)^2 \sin(\pi + h)}{h} \)

(a) Find a function \( f(x) \) and a point \( a \) so that \( L = f'(a) \).

(b) Use derivatives to find the value of \( L \).

3. If \( f(x) \) is differentiable, find the following in terms of \( f' \) :

(a) \( \frac{d}{dx} \frac{f(x)}{1 + \cos^2 x} \)

(b) \( \frac{d}{dx} f(f(x)) \)

4. A particle starts at \( x = 0 \), and moves along the \( x \)-axis so that its velocity is \( v(t) = 3 - \sqrt{t} \) m/s for \( t \geq 0 \).

(a) Find its position at a general time \( t \).

(b) Find the largest \( x \)-coordinate that the particle reaches.
5. Consider \( \lim_{n \to \infty} \sum_{i=1}^{n} \sqrt{\frac{2i}{n}} \left( 3 + \frac{4i}{n} \right) \cdot \frac{2}{n} \).

   (a) Write this limit as an integral, with a specified integrand and limits of integration.  

   (b) Evaluate this integral.

6. Let \( f(x) = \begin{cases} 
   x + 2 & \text{if } x < 0 \\
   \sqrt{4 - x^2} & \text{if } 0 \leq x \leq 2
\end{cases} \)

   Use geometry to evaluate \( \int_{-3}^{2} f(x) \, dx \)

7. (a) State the Fundamental Theorem of Calculus in the derivative form.

   (b) If \( g(x) = \int_{3}^{x} \frac{1}{4 - t^2} \, dt \) for \( t > 2 \), find \( g'(x) \).
(c) Find \( \frac{d}{dx} \int_{x}^{x^2} \sin(t^2) \, dt \)

8. (a) State the **Fundamental Theorem of Calculus** in the antiderivative form.

5 points

(b) Evaluate \( \int_{1}^{4} \frac{1}{\sqrt{x}} + x^3 \, dx \)

5 points

(c) Evaluate \( \int_{1}^{3} \left( \frac{x^2 + 1}{x} \right)^2 \, dx \)

10 points

9. Evaluate \( \int_{0}^{(\pi/6)^{1/4}} x^3 \sec^2(x^4 + \frac{\pi}{6}) \, dx \)

10 points
10. Evaluate \( \int x\sqrt{1-x} \, dx \)

11. Find the finite area bounded by \( x \geq 0, y = x \) and \( y = \sin \left( \frac{\pi}{2} x \right) \).

12. The region bounded by \( y = 0, y = \sqrt{1-x^4}, x = 0 \) and \( x = 1 \) is rotated about the \( x \)-axis. Find the \textit{volume} of the resulting solid.