1. Which of the following represents the area of the shaded region in the figure above?

(A) \( \int_{c}^{d} f(y) \, dy \)  
(B) \( \int_{a}^{b} (d - f(x)) \, dx \)  
(C) \( f'(b) - f'(a) \)  
(D) \( (b-a)[f(b) - f(a)] \)  
(E) \( (d-c)[f(b) - f(a)] \)

2. If \( x^3 + 3xy + 2y^3 = 17 \), then in terms of \( x \) and \( y \), \( \frac{dy}{dx} = 

(A) \(-\frac{x^2 + y}{x + 2y^2}\)  
(B) \(-\frac{x^2 + y}{x + y^2}\)  
(C) \(-\frac{x^2 + y}{x + 2y}\)  
(D) \(-\frac{x^2 + y}{2y^2}\)  
(E) \(-\frac{x^2}{1 + 2y^2}\)

3. \( \int \frac{3x^2}{\sqrt{x^3 + 1}} \, dx = 

(A) 2\sqrt{x^3 + 1} + C  
(B) \frac{3}{2} \sqrt{x^3 + 1} + C  
(C) \sqrt{x^3 + 1} + C  
(D) \ln \sqrt{x^3 + 1} + C  
(E) \ln(x^3 + 1) + C \)
4. For what value of $x$ does the function $f(x) = (x-2)(x-3)^2$ have a relative maximum?

(A) $-3$  (B) $\frac{-7}{3}$  (C) $\frac{-5}{2}$  (D) $\frac{7}{3}$  (E) $\frac{5}{2}$

5. If $f(x) = \sin\left(\frac{x}{2}\right)$, then there exists a number $c$ in the interval $\frac{\pi}{2} < x < \frac{3\pi}{2}$ that satisfies the conclusion of the Mean Value Theorem. Which of the following could be $c$?

(A) $\frac{2\pi}{3}$  (B) $\frac{3\pi}{4}$  (C) $\frac{5\pi}{6}$  (D) $\pi$  (E) $\frac{3\pi}{2}$

6. If $f(x) = (x-1)^2 \sin x$, then $f'(0) =$

(A) $-2$  (B) $-1$  (C) $0$  (D) $1$  (E) $2$

7. The acceleration of a particle moving along the $x$-axis at time $t$ is given by $a(t) = 6t - 2$. If the velocity is 25 when $t = 3$ and the position is 10 when $t = 1$, then the position $x(t) =$

(A) $9t^2 + 1$  (B) $3t^2 - 2t + 4$  (C) $t^3 - t^2 + 4t + 6$  (D) $t^3 - t^2 + 9t - 20$  (E) $36t^3 - 4t^2 - 77t + 55$
8. \( \frac{d}{dx} \int_0^x \cos(2\pi u) \, du \) is

(A) 0 \hspace{1cm} (B) \frac{1}{2\pi} \sin x \hspace{1cm} (C) \frac{1}{2\pi} \cos(2\pi x) \hspace{1cm} (D) \cos(2\pi x) \hspace{1cm} (E) 2\pi \cos(2\pi x)

9. The graph of the function \( f \) is shown above for \( 0 \leq x \leq 3 \). Of the following, which has the least value?

(A) \( \int_1^3 f(x) \, dx \)

(B) Left Riemann sum approximation of \( \int_1^3 f(x) \, dx \) with 4 subintervals of equal length.

(C) Right Riemann sum approximation of \( \int_1^3 f(x) \, dx \) with 4 subintervals of equal length.

(D) Midpoint Riemann sum approximation of \( \int_1^3 f(x) \, dx \) with 4 subintervals of equal length.

(E) Trapezoidal sum approximation of \( \int_1^3 f(x) \, dx \) with 4 subintervals of equal length.

10. What is the minimum value of \( f(x) = x \ln x \)?

(A) \(-e\) \hspace{1cm} (B) \(-1\) \hspace{1cm} (C) \(-\frac{1}{e}\) \hspace{1cm} (D) 0 \hspace{1cm} (E) \( f(x) \) has no minimum value.
11. (1999, AB-5) The graph of the function $f$, consisting of three line segments, is shown above. Let

$$g(x) = \int_{1}^{x} f(t) \, dt.$$  

(a) Compute $g(4)$ and $g(-2)$.

(b) Find the instantaneous rate of change of $g$, with respect to $x$, at $x = 1$.

(c) Find the absolute minimum value of $g$ on the closed interval $[-2, 4]$. Justify your answer.

(d) The second derivative of $g$ is not defined at $x = 1$ and $x = 2$. How many of these values are $x$-coordinates of points of inflection of the graph of $g$? Justify your answer.
12. (1998, AB-4) Let \( f \) be a function with \( f(1) = 4 \) such that for all points \((x, y)\) on the graph of \( f \) the slope is given by \( \frac{3x^2 + 1}{2y} \).

(a) Find the slope of the graph of \( f \) at the point where \( x = 1 \).

(b) Write an equation for the line tangent to the graph of \( f \) at \( x = 1 \), and use it to approximate \( f(1.2) \).

(c) Find \( f(x) \) by solving the separable differential equation \( \frac{dy}{dx} = \frac{3x^2 + 1}{2y} \) with the initial condition \( f(1) = 4 \).

(d) Use your solution from part (c) to find \( f(1.2) \).