1) Let \( f \) be the function defined by
\[
    f(x) = \begin{cases} 
        \sin x & x < 0 \\
        x^2 & 0 \leq x < 1 \\
        2 - x & 1 \leq x < 2 \\
        x - 3 & x \geq 2.
    \end{cases}
\]

For what values of \( x \) is \( f \) not continuous?
(A) 0 only
(B) 1 only
(C) 2 only
(D) 0 and 2 only
(E) 0, 1, and 2

2) The graph of which of the following has \( y = 1 \) as an asymptote?

(A) \( y = \ln x \)
(B) \( y = \cos x \)
(C) \( y = \frac{x}{x+3} \)
(D) \( y = \frac{2x^2}{x-1} \)
(E) \( y = e^{-x} \)
3) \( \frac{d}{dx}(\arcsin x^2) = \)

(A) \( \frac{1}{\sqrt{1-x^4}} \)
(B) \( \frac{x}{\sqrt{1-x^4}} \)
(C) \( \frac{2x}{\sqrt{x^4-1}} \)
(D) \( \frac{2x}{\sqrt{1-x^4}} \)
(E) \( -\frac{2x}{\sqrt{1-x^4}} \)

4) At which of the following points is the second derivative of \( x^4 - 6x^3 + 12x^2 + 2x + 2 \) negative?

(A) \( \frac{1}{2} \)
(B) \( 1 \)
(C) \( \frac{3}{2} \)
(D) \( \frac{5}{2} \)
(E) \( \frac{7}{2} \)
5) Find the linear approximation of \(\sqrt{16 + u}\) when \(u\) is close to 0.

(A) \(2 + \frac{u}{32}\)
(B) \(2 - \frac{u}{32}\)
(C) \(4 - \frac{u}{32}\)
(D) \(4 + \frac{u}{32}\)
(E) \(\frac{u}{32}\)

6) Find \(\int_{-1}^{2} (1 - 2f(x)) \, dx\) assuming that \(\int_{-1}^{1} f(x) \, dx = 1\) and \(\int_{1}^{2} f(x) \, dx = -3\).

(A) \(-5\)
(B) \(-2\)
(C) \(0\)
(D) \(2\)
(E) \(7\)
7) \[ \int_{0}^{1} (x + 1) e^{x^2+2x} \, dx = \]

(A) \( \frac{e^3-1}{2} \)

(B) \( \frac{e^4-e}{2} \)

(C) \( \frac{e^4}{2} \)

(D) \( e^4 - e \)

(E) \( e^3 - 1 \)

8) Find the \( \lim_{x \to +\infty} xe^{x} \sin \frac{1}{x} \)

(A) Does not exist

(B) \(+\infty\)

(C) \(0\)

(D) \(1\)

(E) \(e\)
9) If \( f(x) = \int_{0}^{\ln x} e^{t^2} \, dt \), then what is \( f'(e) \)?

- (A) \( e \)
- (B) \( \frac{1}{e^2} \)
- (C) \( 1 \)
- (D) \( e^2 \)
- (E) \( \frac{1}{e} \)

10) A particle moves in a straight line with velocity at any time \( t \) given by \( v(t) = e^t \). Find the distance traveled by the particle during the time period from \( t = 0 \) to \( t = 2 \).

- (A) \( e^2 - 1 \)
- (B) \( \frac{e^3}{3} \)
- (C) \( e^2 + 1 \)
- (D) \( 2e \)
- (E) \( e^2 \)
11) The region enclosed by the graph of \( y = x^2 \), the line \( x = 2 \), and the \( x \)-axis is revolved about the \( y \)-axis. The volume of the solid generated is

- (A) \( \frac{32}{5} \pi \)
- (B) \( \frac{16}{3} \pi \)
- (C) \( 4\pi \)
- (D) \( 8\pi \)
- (E) \( \frac{8}{3} \pi \)

12) The substitution \( u = \sqrt{x} \) turns \( \int_{2}^{3} e^{\sqrt{x}} \, dx \) into

- (A) \( \int_{\sqrt{2}}^{\sqrt{3}} e^{u} \, du \)
- (B) \( \int_{\sqrt{2}}^{\sqrt{3}} 2ue^{u} \, du \)
- (C) \( \int_{\sqrt{2}}^{\sqrt{3}} \frac{1}{2} \, du \)
- (D) \( \int_{4}^{9} e^{u} \, du \)
- (E) \( \int_{4}^{9} 2ue^{u} \, du \)
13) The average value of the function \( f(x) = \frac{(1+\sqrt{2})^2}{x} \) on the interval \([1, 4]\) is

(A) \( 7 + \ln 4 \)

(B) \( \frac{7 + 2\ln 2}{3} \)

(C) \( \frac{(\sqrt{2}+1)^2}{6} \)

(D) \( \frac{9}{12} \)

(E) \( \frac{4}{3} \)
14) (26 points) (a) If $3x^2 - 2xy + y^2 = 3$, find $\frac{dy}{dx}$.

(b) Find the equation of the tangent to the curve $3x^2 - 2xy + y^2 = 3$ at the point $(1,2)$.
15) (26 points) Show that the equation $2x + \cos^2 x = 1$ has exactly one real solution.
16) (20 points) You are to make a cylindrical can of volume $128\pi$ cm$^3$. The material for the base and the top costs $2/\text{cm}^2$, while the material for the side costs $1/\text{cm}^2$. Find the height and the radius of the can that will minimize the cost.
17) (35 points) Consider the function \( f(x) = 3x^5 - 10x^3 + 2 \).

(a) Find the critical points and determine which ones are local maxima and minima.

(b) Determine where the function is increasing and decreasing.

(c) Find the inflection points.

(d) Determine where the function is concave upwards and concave downwards.

(e) Sketch the graph of \( f(x) \).
18) (20 points) Compute the area bounded by the curves $y = 4x$ and $y = x^2 + x + 2$. 
19) (30 points) (a) Find the intervals of increase or decrease and the absolute maximum value of the function \( f(x) = \frac{\ln x}{x} \).

(b) Using part (a), show that \( \frac{1}{e} > \frac{\ln \pi}{\pi} \).

(c) Conclude that \( e^\pi > \pi^e \).