1. Find the following derivatives.

i Find $g'(x)$, where $g(x) = x^{\sqrt{x}}$.

ii If $xy + e^y = e$, find the value of y' and y'' at the point where $x = 0$.

iii Find $f'(x)$, where $f(x) = \begin{cases} x^3 \sin \dfrac{2}{x^2} & , \quad x \neq 0 \\ 0 & , \quad x = 0 \end{cases}$

(Hint: Use the definition to compute $f'(0)$ separately.)

2. Find the following integrals.

i Find $\int x^2 \ln x \, dx$.

ii Find $\int \cos^3 x \, dx$.

iii Find $\int x \cos^3 x \, dx$. Hint: Use integration by part and ii.

iv Find $\int \sec^3 x \, dx$. Hint: Use integration by parts and $\tan^2 x = \sec^2 x - 1$.

v Find $\int_0^1 \sqrt{x^2 + 1} \, dx$. Hint: Use iv.

vi Find $\displaystyle\int_0^1 \frac{x^3 - 3x - 3}{x^2 - x - 6} \, dx$

vii Find $\displaystyle\int \frac{1}{x^2 + x + 1} \, dx$

3. Find the following area or volume.

i Find the region enclosed by $4x + y^2 = 12$ and $x = y$.

ii Find the volume of the solid obtained by rotating the region bounded by $y = \frac{1}{4}x^2$ and $y = 5 - x^2$ about the x-axis.

4. Find equations of both lines through the points $(2, -3)$ that are tangent to the parabola $y = x^2 + x$.

5. Consider the graph of $y = f(x) = 3x^4 - 4x^3 - 12x^2 + 1$.

i Find the intervals of increase or decrease.

ii Find all local maximum and minimum value of $f(x)$.

iii Find the intervals on which f is concave upward or downward and all inflection points.

iv Sketch the graph.

6. Find the point on the line $y = 2x + 3$ that is closest to the origin.