1. Let $f(x, y) = \sin(x + y)$ and let $P = (\pi/2, \pi/2)$.

   (a) Calculate the derivative of $f$ in the direction of the vector $\vec{v} = \langle 2, 4 \rangle$.

   (b) Find the direction of maximum increase of $f$ at $P$ and find the maximum rate of increase.
2. Let $f(x, y) = x^2 - y^2$.

(a) Find the critical points of $f$ and classify them as maxima, minima, or saddle points.

(b) Find the absolute extrema of $f$ over the domain $D = \{(x, y) : -1 \leq x \leq 1, -1 \leq y \leq 1\}$. 
3. (a) Using the chain rule, find \( \frac{dz}{dt} \) if \( z = e^{xy} \tan(y) \) and \( x = s + t, y = st \).

(b) Using the chain rule, find \( \frac{\partial z}{\partial t} \) where \( z = x^2 + y^2 + w^2 \) and \( x = st, y = s \cos(t) \) and \( w = s \sin(t) \).
4. Evaluate the integrals

(a) \( \iint_D (x^2 + y^2) \, dA \) where \( A = [2, 4] \times [-1, 1] \)

(b) \( \iint_D y \cos(xy) \, dx \, dy \) over \( 0 \leq x \leq 1, 0 \leq y \leq \pi \).
5. Evaluate the integrals

(a) Find the volume under the surface \( z = 1 - x^2 - y^2 \) lying over the triangle with vertices \((\pm 1, 0)\) and \((0,1)\)

(b) Find \( \iint_D xy \, dA \) where \( D \) is the region enclosed by the curves \( y = x \) and \( y = x^2 \).