1. Find both first-order partial derivatives of both the functions

\[ f(x, y) = e^{3y} \sin(x) \]
\[ g(x, y) = xy^2 \ln(3x) \]

2. Find the matrix of partial derivatives of the function

\[ F(x, y, z) = (ze^{x^2 + y^2} + xy, \cos(x^3 y^2 z^4)) \]

3. A function \( f(x, y) \) is harmonic if it satisfies the Laplace equation \( \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = 0 \)

Show that \( f(x, y) = x^3 - 3xy^2 \) is harmonic.

4. The heat equation is: \( \frac{\partial u}{\partial t} = k^2 \frac{\partial^2 u}{\partial x^2} \). Show that \( u(x, t) = e^{-k^2t} \sin(x) \) is a solution of the heat equation.
5. Let $f(x, y) = x^2 + \frac{1}{2}y^2 - 2x$ Find a point on the graph $z = f(x, y)$ where the tangent plane is horizontal.

6. Let $f(x, y) = \frac{x}{y} + \frac{y}{x}$. Using a linear approximation about the point $(1/2, 1/4)$, estimate the value of $f(.48, .3)$.

7. An ant is trying to get out of the parabolic bowl $z = x^2 + 3y^2$. Suppose the ant is currently at the point $x = 2, y = -1, z = 7$. In which direction should the ant set out in order to climb out of the bowl fastest? Should it follow a straight line path from then on?