1.) Show that \( T = \frac{1}{\sqrt{x^2 + y^2}} \) satisfies the equation \( \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = T^3 \).

2.) Find \( z_x, z_y, z_{xx}, z_{yy}, \) and \( z_{xy} \) for \( z = \ln(xy^2 + 3) \).

3.) Find a function \( z = f(x, y) \) with the following partial derivatives or state that this is impossible:

\[
\begin{align*}
z_x &= e^{x^2y} \cos x + 2xye^{x^2y} \sin x + 2xy^3 + 1 \\
z_y &= x^2e^{x^2y} \sin x + 3x^2y^2 + 2ye^{y^2}.
\end{align*}
\]

4.) Assume that \( u = f(x, y), x = r \cos \theta, \) and \( y = r \sin \theta \). Compute \( \frac{\partial u}{\partial r}, \frac{\partial u}{\partial \theta}, \) and \( \frac{\partial^2 u}{\partial \theta^2} \).

5.) Find an equation of the plane tangent to the surface \( z = y^2 - x^2 \) at the point \((2, 1, -3)\).

6.) Find the point on the plane \( 3x + 2y + z = 12 \) which is nearest the origin.

7.) a.) Show that \((0, 0)\) is a critical point for \( z = x^4 - 2x^2y^2 + y^4 \). Show that \((0, 0)\) determines a minimum value.

b.) Show that \((0, 0)\) is a critical point for \( z = 2x^4 + 4x^3y + y^4 \). Show that \((0, 0)\) determines a saddle point.

c.) Show that \((0, 0)\) is a critical point for \( z = (y - x^2)(y - 2x^2) \). Show that \((0, 0)\) determines a saddle point.

8.) A house in the shape of a rectangular box is to hold 10,000 cubic feet. The four walls admit heat at 5 units per minute per square foot. The roof admits heat at 3 units per minute per square foot. The floor admits heat at 2 units per minute per square foot. What should the dimensions (length, width, height) of the house be in order to minimize the rate (units per minute) at which heat enters?