1. Identify and sketch the graph of the surface $4x^2 + y^2 - z^2 = 1$.

2. The position of a particle at time $t$ is $\vec{r}(t) = t \ln(t + 1) \vec{i} + (t + 1)^{1/2} \vec{j} + (t + 1)^{3/2} \vec{k}$

   (a) Find the velocity and acceleration vectors
(b) Find an equation for the tangent line to the path (in part (a)) of the particle when \( t = 0 \).

3. Solve the initial problem for \( \vec{r} \) as a vector function of \( t \) if

\[
\text{(10)} \quad \text{Differential equation:} \quad \frac{d\vec{r}}{dt} = te^{-t}\hat{i} + e^{-t}\hat{j} - e^{-2t}\hat{k} \\
\text{Initial Condition:} \quad \vec{r}(0) = -\hat{i} + \hat{j} + 2\hat{k}
\]

(8) 4. Find the length of the curve \( \vec{r} = \frac{1}{3}t^{3/2}\hat{i} + 2t\hat{j} + \frac{1}{\sqrt{3}}t^{3/2}\hat{k} \), \( 2 \leq t \leq 7 \).
5. (a) Find and sketch the domain of the function \( f(x, y) = \sqrt{x^2 + 4y^2 - 9} \).

(b) Find an equation for and sketch the graph of the level curve of the function \( f(x, y) \) of part (a) that passes through the point \((3, -1)\).
6. Find the limit. \[ \lim_{(x,y) \to (2,-2)} \frac{x + y}{x^2 - y^2} \]

7. By considering different paths of approach, show that \( f(x, y) \) has no limit as \( (x, y) \to (0, 0) \).
\[ f(x, y) = \frac{y^2 + xy}{x^2 + y^2} \]

8. Find all the second partial derivatives of \( f(x, y) = \ln(x + y^2) \)
9. Suppose we substitute \( x = u^2 - v^2 \) and \( y = 2uv \) in a differentiable function \( w = f(x, y) \). Show that

\[
\frac{1}{2} \frac{\partial w}{\partial u} = \frac{\partial f}{\partial x} u + \frac{\partial f}{\partial y} v
\]

and derive a comparable expression for \( \frac{\partial w}{\partial v} \).

10. (a) Find the gradient of the function \( f(x, y, z) = xy + 2yz + 3xz \).

(b) Find the (directional) derivative of \( f \) at \( P_0(1, 3, -1) \) in the direction of \( \vec{u} = \vec{i} - \vec{j} + 2\vec{k} \).