No. 1. (15 points) The length \( l \), width \( w \) and height \( h \) of a box change with time. At a certain instant the dimensions are \( l = 1 \) m and \( w = h = 2 \) m, and \( l \) and \( w \) are increasing at the rate of 2 m/s while \( h \) is decreasing at a rate of 3 m/s. At that instant find the rates at which the following quantities are changing. Include units.

a) The surface area.

b) The volume.

c) The length of a diagonal.
No. 2. (15 points) Let
\[ f(x, y) = 5xy^2 - 4x^3y. \]

a) Find the gradient vector field of \( f(x, y) \).
\[ \nabla f = \]

b) Find the gradient vector of \( f(x, y) \) at \( P(1, 2) \).

c) Find the directional derivative of \( f(x, y) \) at \( P(1, 2) \) in the direction of the vector \( v = <5, 12> \).

d) Find the value of the largest directional derivative of \( f(x, y) \) at \( (x, y) = (1, 2) \).

e) Find a vector which points in the direction in which the largest directional derivative of part c) occurs.
No. 3. (15 points)

a) Find the first partial derivatives of the function

\[ f(x, t) = \arctan(x\sqrt{t}). \]

b) Determine the set of points at which the function

\[ G(x, y) = \ln(x^2 + y^2 - 4) \]

is continuous. Describe the set.
No. 4. (20 points) Find the equation for the tangent plane to the given surface at the specified point.

a) to $z = \sqrt{4 - x^2 - 2y^2}$ at $(x, y, z) = (1, -1, 1)$.

b) to $x^2 - 2y^2 + z^2 + yz = 2$ at $(x, y, z) = (2, 1, -1)$. 
No. 5. (20 points) Let
\[ f(x, y) = 2x^3 + xy^2 + 5x^2 - y^2. \]

Find all points \((x, y)\) which are critical points for \(f(x, y)\). Then apply the second partials test to each critical point to determine whether it gives a local maximum point, a local minimum point or a saddle point.
No. 6. (15 points) Use the method of Lagrange multipliers to find the largest value and smallest value for

\[ f(x, y, z) = xyz \]

subject to

\[ 3z^2 = 6 - x^2 - 2y^2. \]