(30) 1. An object is moving in a 3-space according to the parametric equations $x = 2t$, $y = t$, $z = 2 \sin t$, where $t$ is the time. Find the followings:

a) Position vector $\mathbf{r} =$

b) Velocity vector $\mathbf{v} =$

c) Acceleration vector $\mathbf{a} =$

d) Speed $=$

e) $a_T =$

f) Curvature $K =$

g) $a_N =$

h) Find $T$ and $N$ at $t = \frac{\pi}{2}$. 
(20) 2. An object is moving in the xy-plane around the circle $x^2 + y^2 = 25$, starting at $t = 0$, in the clockwise direction. Its speed is $2(1 + \sin t)$ ft/sec.

a) Find $a_T$ and $a_N$ as a function of $t$.

b) Suppose that at $t = \frac{\pi}{2}$, the object is at $(x, y) = (4, 3)$. Find the velocity vector and the acceleration vector at this point.
(20)3. Suppose that \( w = f(x, y), \ x = s^2 t, \ y = \frac{s}{t} \). Suppose that \( \frac{\partial f}{\partial x} = 1 \) and \( \frac{\partial f}{\partial y} = 2 \) at \((x, y) = (4, 2)\). Use the chain rule to find the partial derivatives of \( f(x, y) \) with respect to \( s \) and \( t \) at \((x, y) = (4, 2)\).
Given \( f(x, y) = xe^y \):

a) Find the gradient vector field \( \nabla f(x, y) \).

b) Find the directional derivative of \( f(x, y) \) at \((x, y) = (2, 1)\) in the direction of the vector \( i + j \).

c) Find the value of the direction of maximum increase of \( f(x, y) \) at \((2, 1)\).
(10)5. Let $3s^2u - s^2t^2 + 2t^3 + 3tu - 5 = 0$. Use implicit differentiation to find $\frac{\partial u}{\partial s}$ and $\frac{\partial u}{\partial t}$. 