(1) (a) Show that the lines $L_1$ and $L_2$ with parametric equations

$L_1$: $x = 1 + 2t$, $y = 3t$, $z = 2 - t$

$L_2$: $x = -1 + s$, $y = 4 + s$, $z = 1 + 3s$

are skew lines.

(b) Find the distance between $L_1$ and $L_2$. 

(10pts)
(2) Identify and sketch the surface $\rho = 2 \cot \phi \csc \phi$.  
(Hint: Express the equation in rectangular coordinate)
(3) Find the limit, if it exists, or show that the limit does not exist.

(i) \[
\lim_{(x,y) \to (0,0)} \frac{\tan(x^2+y^2)}{x^2+y^2}.
\]

(ii) \[
\lim_{(x,y,z) \to (0,0,0)} \frac{xy+yz+zx}{x^2+y^2+z^2}.
\]

(4) Find the linear approximation of the function \( f(x, y) = x^\alpha y^\beta \) at \((1,1)\).
(5) Using implicit differentiation, find $\frac{\partial z}{\partial x}$ and $\frac{\partial z}{\partial y}$ for $xyz = \cos(x + y + z)$. (10pts)

(6) Find the directional derivative $D_u f(1, 2)$ if $f(x, y) = x^3 - 3xy + 4y^2$ and $u$ is the unit vector given by the angle $\theta = \frac{\pi}{6}$. (10pts)
(7) Find the equations of the tangent plane and normal line at the point \((4, -1, 1)\) to the Ellipsoid \(x^2 + 2y^2 + 3z^2 = 21\). (10pts)
(8) Locate all relative maxima, relative minima, and saddle points for
\[ f(x, y) = x^3 + y^2 - 12x + 6y - 7. \]