1. (2 points) Let $f(x, y) = x^2 - xy + y^2 - y$. Find the directions $\vec{u}$ and the values of $D_{\vec{u}}f(1, -1)$ for which

a. $D_{\vec{u}}f(1, -1)$ is largest

b. $D_{\vec{u}}f(1, -1)$ is smallest

c. $D_{\vec{u}}f(1, -1) = 0$

d. $D_{u}f(1, -1) = 4$

e. $D_{\vec{u}}f(1, -1) = -3$

2. (2 points) Find equations for the

(a) tangent plane and

(b) normal line at the point P_0 on the given surface.

$$x^2 + 2xy - y^2 + z^2 = 7, \quad P_0(1, -1, 3)$$

3. (2 points) Find the linearization $L(x, y, z)$ of the function $f(x, y, z)$ at P_0. Then find an upper bound for the magnitude of the error E in the approximation $f(x, y, z) \approx L(x, y, z)$ over the region R.

$$f(x, y, z) = xz - 3yz + 2 \text{ at } P_0(1, 1, 2)$$
$$R: \ |x - 1| \leq 0.01, \ |y - 1| \leq 0.01, \ |z - 2| \leq 0.02$$

4. (2 points) Find all the local maximam, local minima, and saddle points of the function

$$f(x, y) = x^3 + 3xy + y^3$$

5. (2 points) Find the absolute maxima and minima of the functions on the given domains. $f(x, y) = 48xy - 32x^3 - 24y^2$ on the rectangular plate $0 \leq x \leq 1, 0 \leq y \leq 1$.