1. (a) (10 points) For the function $f(x,y) = \sqrt{x - y^2 + 4}$, find and sketch the domain. Find an equation for the level curve of $f(x,y)$ passing through the point $(4,2)$.

   (b) (10 points) Find all the second order partial derivatives of $g(x,y)$.

$$g(x,y) = y\cos(x) + \ln(x^2 y) + \frac{x^2}{y}.$$

2. (a) (10 points) Find $\partial w/\partial u$ when $u = -\pi$, $v = \pi$ if $w = xy + \ln(z)$, $x = v^2/u$, $y = u + v$, $z = \cos u$.

   (b) (10 points) Find the directional derivative of $f(x,y,z) = e^x \sin(4y + 3z)$ at $P_0(0,0,0)$ in the direction of $\mathbf{v} = \mathbf{i} + 2\mathbf{j} - 2\mathbf{k}$. Find a unit vector in the direction where the function increases most rapidly at P_0.

3. (a) (7 points) Find equations for the tangent plane and normal lines at the point P_0 on the given surface.

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

   (b) (8 points) Find the linearization $L(x,y,z)$ of the function $f(x,y,z)$ at the point P_0.

$$f(x,y,z) = \frac{\sin(xy)}{z}, \qquad P_0(\frac{\pi}{2},1,1).$$

4. (a) (15 points) Find all the local maxima, local minima, and saddle points of the function

$$f(x,y) = 2x^3 + 2y^3 - 3x^2 + 3y^2$$

   (b) (10 points) Find the maximum and minimum values of $f(x,y,z) = 5x + y - 2z$ on the sphere $x^2 + y^2 + z^2 = 30$.

5. (a) (8 points) valuate the double integral over the given region R.

$$\iint_R \frac{3xy^2}{x^2+1} dxdy, \qquad R:\ 0 \le x \le 1,\ 0 \le y \le 2.$$

   (b) (12 points) Sketch the region of integration, reverse the order of integration, and evaluate the integral

$$\int_0^3 \int_{\sqrt{x/3}}^1 e^{y^3}\, dydx.$$