Let \( f(x, y) = 3x^2 + 6xy - 2y^3 \).

(a) Find the directional derivative of \( f \) in the direction of \( 3 \hat{i} + \hat{j} \). [5 pts]

(b) Find the two critical points for \( f \). [6 pts]

(c) For each critical point, determine if that critical point is a relative minimum, relative maximum, or saddle point. [9 pts]

2. (a) Let \( f(x, y) = |x| + y \). On a single plane draw the level curves for \( c = 0, 1 \) and \( 2 \) and label each with its value of \( c \). [10 pts]

(b) Find the parametric equations of the line which is perpendicular to the surface \( f(x, y) = x^2y + y^3 \) at the point \((1, 2)\). [10 pts]

3. (a) Sketch the surface \( z = 1 + \sqrt{x^2 + y^2} \). Be sure to include some points or tick marks to give a sense of scale/position. [5 pts]

(b) Sketch the surface \( z = 2 \). Be sure to include some points or tick marks to give a sense of scale/position. [5 pts]

(c) Write down the equation for the cylinder of radius 3 which runs along the \( x \)-axis. [5 pts]

(d) Write down the equation for the paraboloid opening down with vertex at \((0, 0, 7)\). [5 pts]

4. Find the maximum and minimum values of the function \( f(x, y) = 3x^2 + y^2 \) on the region \( x^2 + y^2 \leq 2, \ y \geq 0 \). [20 pts]

5. Use Lagrange multipliers to find the maximum and minimum values of the function \( f(x, y) = xy + 2x \) on the curve \( x^2 + y^2 = 4 \). [20 pts]