Instructions: Put your solutions on a separate piece(s) of paper. You may use this page as a cover sheet. Submission for credit: Submit it in recitation on Thursday, Nov. 14.

Generally it is good to explain your work: an important facet of mathematics is explaining how you arrived at the answer, and not just stating the answer. (On exams you will be required to show your work.)

(1) Find an equation for the tangent plane to each surface below at the indicated point.

(a) The graph of \( z = f(x, y) = x^2 - y^3 \) at the point on the surface corresponding to \( x = 2 \) and \( y = 1 \)

(b) The graph of \( z = f(x, y) \) implicitly defined by \( xy + xz + yz - \ln (z^2 + 1) = 4 \) at the point \((2, 2, 0)\).

(2) The volume of a cylinder of radius \( r \) cm and height \( h \) cm is \( V(r, h) = \pi r^2 h \) (in units of cm\(^3\)).

(a) Compute \( V(2, 5) \).

(b) Find the linear approximation to the volume \( V \) at the point \((2, 5)\).

(c) Now use part (b) to estimate the volume if the radius is decreased by \( 1/(2\pi) \) cm while the height is increased by \( 1/(2\pi) \) cm.

(3) Find all four critical points of \( f(x, y) = 2xy^2 - x^2y - 3xy \).

(4) Let \( g(x, y) = xye^{-x^2-y^2} \).

(a) Find all critical points.

(b) Classify the critical points found in part (a).

(5) Suppose we know that the partial derivatives of \( f(x, y) \) are \( f_x = 6(x^2 - 1)(y + 1) \) and \( f_y = 2x(x^2 - 3) \).

(a) Find all critical points.

(b) Classify the critical points found in part (a).
Suppose $f(x, y)$ has continuous partial derivatives and that below are the level curves of $f_x$ (solid) and $f_y$ (dashed). Estimate the coordinates of the critical points of $f(x, y)$. 

(6) Suppose $f(x, y)$ has continuous partial derivatives and that below are the level curves of $f_x$ (solid) and $f_y$ (dashed). Estimate the coordinates of the critical points of $f(x, y)$.