

Please show all work and **box your final answers**. If you need more room, you may use the backs of the pages. Calculators are not allowed. Good luck!

1. Let  $f(x, y) = y - \sqrt{x}$ .

(a) (4 points) Sketch the domain of  $f$ .

(b) (4 points) Draw a contour map of the function showing several level curves.

2. (4 points) Show that the following function is not continuous at  $(0,0)$ .

$$f(x, y) = \begin{cases} \frac{x^4 - 2y^2}{x^2 + y^2} & \text{if } (x, y) \neq (0, 0) \\ 0 & \text{if } (x, y) = (0, 0) \end{cases}$$

3. (4 points) Give an equation for the tangent plane to the surface  $z = \frac{2x + 3}{4y + 1}$  at the point  $(0, 0, 3)$ .

4. Let  $z = \ln \sqrt{x^2 + y^2}$

(a) (4 points) Find the differential  $dz$ .

(b) (4 points) Use  $dz$  to approximate the change in  $z$  as  $(x, y)$  changes from  $(1, 3)$  to  $(0.9, 3.1)$ .

5. Suppose

$$N = pq + q^r, \quad p = u + vw, \quad q = v + uw, \quad r = w + uv.$$

(a) (4 points) Draw a tree diagram (or a “bush diagram”) to show how  $N$  is a function of  $u, v$ , and  $w$ .

(b) (4 points) Find  $\frac{\partial N}{\partial w}$  in terms of  $p, q, r, u, v$ , and  $w$ .