Print Your Name Legibly: \_\_\_\_\_

Score: \_\_\_\_\_

**Instructions:** You must show supporting work to receive full and partial credits. Textbook, notes, cheat sheets, calculators are not allowed.

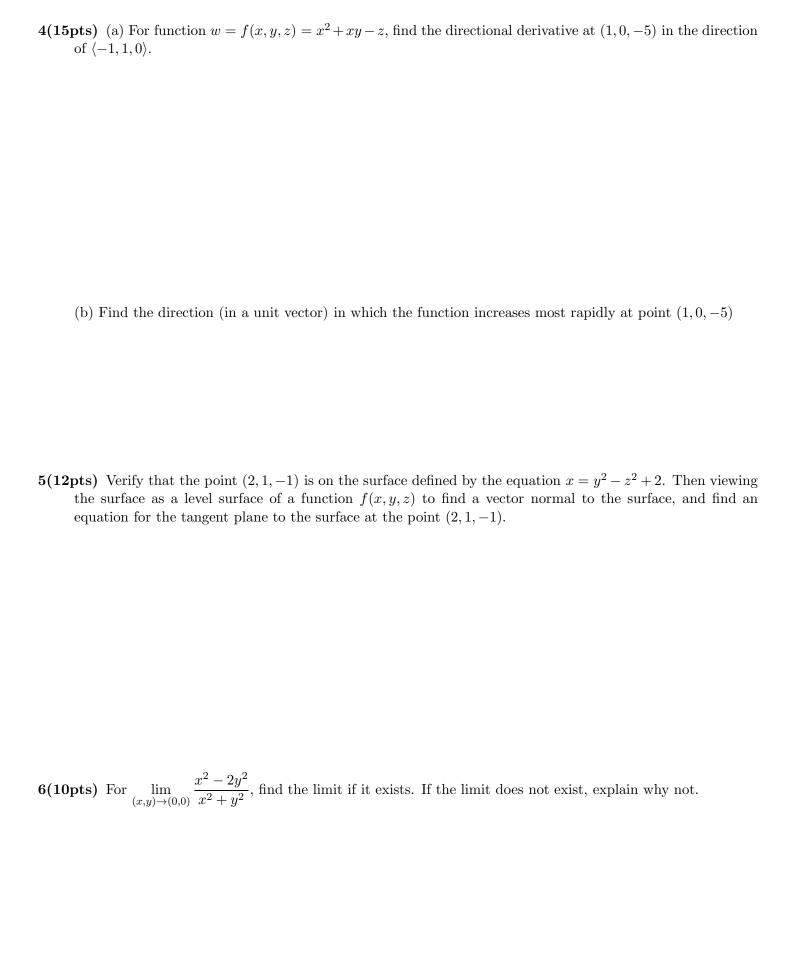
**1(10pts)** For function f(x,y) = 2x + y, sketch a contour diagram with at least 4 labeled contours. Describe in words the contours and how they are spaced.

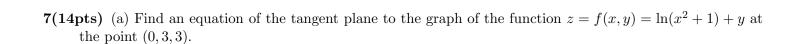
**2(15pts)** Let  $\vec{u} = \langle 1, -1, 1 \rangle$ ,  $\vec{v} = \langle 1, 0, 1 \rangle$ . Find the following.

(a) The angle between  $\vec{u}$  and  $\vec{v}$ .

(b) A vector  $\vec{w}$  perpendicular to both vectors.

**3(10pts)** An object moves from point P = (1, 0, 2) to Q = (2, -1, 2), and a force,  $\vec{F} = \langle 1, 0, 1 \rangle$ , acts on the object. Find the projection of  $\vec{F}$ ,  $\vec{F}_{\text{parallel}}$ , in the direction of  $\vec{PQ}$ .





(b) Estimate the value of f(0,3.2) by the linearization.

**8(14pts)** (a) For functions  $z = f(x, y) = xe^y$ ,  $x = u(s, t) = \ln s$ , and  $y = v(s, t) = \sin(s + t)$ , use the chain rule to find  $\frac{\partial z}{\partial s}$ . (Simplification is not needed.)

(b) Find the value of  $\frac{\partial z}{\partial s}$  at (s,t)=(1,-1).