1. a) Identify and sketch the surface described by $20x^2 - 16y^2 + 5z^2 = 80$.
   Hyperboloid of one sheet, oriented along the y-axis.

b) Find all points on the surface $20x^2 - 16y^2 + 5z^2 = 80$ where the tangent plane is horizontal.
   $(0, 0, 4)$ and $(0, 0, -4)$

c) Find the equation for the plane tangent to the surface $20x^2 - 16y^2 + 5z^2 = 80$ at the point $(1, 0, 2\sqrt{3})$.
   $2x + \sqrt{3}z = 8$

2. a) Find the limit.
   $\lim_{(x,y) \to (0,0)} \frac{14y + (x \ln x) \sin y}{\sin y}$
   $14$

b) Show that the limit of $f(x, y) = \frac{5xy}{2x^4 + y^2}$ as $(x, y) \to (0,0)$ does not exist.
   Approach along two different paths (like $y = 0$ and $y = x$) and get two different results.

3. Find $\nabla f$ for $f(x, y) = \sin(xy^2) - \ln(y \cos x)$ at $(\pi, -7)$.
   $\left\langle -49, 14\pi + \frac{1}{7} \right\rangle$

4. Find $D_u f(15, 8)$ for $f(x, y) = \sqrt{x^2 + y^2}$ in the direction of $\vec{v} = (1, -3)$.
   $D_u f(15, 8) = \frac{-9}{17\sqrt{10}}$

If a traveler leaves the point $(15, 8)$ on this surface and travels in the direction of $\vec{v}$, will the traveler be going uphill, downhill, or traveling along a level curve?

Circle one: downhill

5. Find the locations of all maxima, minima, or saddle points of $f(x, y) = x^3 + 3xy^2 - 15x + y^3 - 15y$.
   List the coordinates of each point and classify the behavior at each location
   List
   $(0, \sqrt{5}), (0, -\sqrt{5})$ are locations of saddle points
   $(2, 1)$ is the location of a minimum
   $(-2, -1)$ is the location of a maximum

6. Find absolute maximum and minimum values of $f(x, y) = x^2 + y^2 + 2x + 2y$ on the triangle with vertices $(0,0)$, $(3,0)$, and $(0,3)$. Identify the type of extreme value at each point.
   List
   $(0, -1, -1)$ and $(-1, 0, -1)$ critical points but are not on the triangle
   $(3/2, \sqrt{2}, 21/2)$
   $(0, 0, 0)$ absolute minimum
   $(0, 3, 15)$ absolute maximum
   $(3, 0, 15)$ absolute maximum
7. Use Lagrange multipliers to find the extreme values of \( f(x, y) = x^2 y \) on the line \( 4x + 5y = 8 \). List the coordinates of each point and classify the behavior at each location.

List
(0, 8/5, 0) is the location of a minimum
(4/3, 8/15, positive) is the location of a maximum

8. a) The picture below shows some level curves of \( f(x, y) \). Which of the three vectors shown in the picture, I, II, or III, points in the direction of steepest descent?

Circle one: I

b) \( w \) is a function of \( r, s, \) and \( t \), where \( r \) is a function of \( q \), \( s \) is a function of \( q \) and \( p \), and \( t \) is a function of \( p \).

Draw a tree diagram for this chain rule formula:
\[
\frac{\partial w}{\partial p} = \frac{\partial w}{\partial s} \cdot \frac{\partial s}{\partial p} + \frac{\partial w}{\partial t} \cdot \frac{\partial t}{\partial p}
\]

EXTRA!!! Match each tortilla chip to an appropriate equation for its surface. (4 points)

a) \( f(x, y) = 18 - 49x - 25y \) 

b) \( f(x, y) = -36x - 4y^2 \)

c) \( f(x, y) = -25x^2 - 10y^2 \) 

d) \( f(x, y) = 16x^2 + 16y^2 \)

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<thead>
<tr>
<th>I</th>
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<tbody>
<tr>
<td>II</td>
<td>a</td>
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