1. Find and classify (as local maxs, mins, saddle points or none of these) any critical points of $f(x, y) = x + y + 1/xy$. 
2. Graph the projection (or shadow) in the xz-plane of the space curve

\[ \mathbf{r}(t) = < 1 + t, -5t, 4t^2 > \]

Label the axes of the plane.

3. Find \( \frac{\partial^2 f}{\partial x \partial y} \) when \( f(x, y) = 3x^2 y + \ln(xy) \).
4. Find the direction in which \( f(x, y) = 3x^2y + \ln(xy) \) increases most rapidly at the point \( P(1, 1) \).

5. Find the equation of the tangent plane to the surface \( z = 3x^2y + \ln(xy) \) at the point \( (1, 1, 3) \).
6. Graph the level curve at level $k = 1$ for the function $f(x, y) = 5 + 4y^2 - 9x^2$. Label the $xy$ axes.
For problems 7-10 below consider the space curve
\[ r(t) = <4t, \sin(3t), \cos(3t)> \]

7. Find the equation of the tangent line, in vector or parametric form, for the tangent line to \( r(t) \) when \( t = 0 \). (Recall that a line is determined by a point and a direction).

8. Find the unit tangent vector to \( r(t) \) at any time \( t \).
9. Find the unit normal vector to \( r(t) \) at any time \( t \).

10. Find the curvature of \( r(t) \) at any time \( t \).
11. Use the method of Lagrange multipliers to find the maximum value of \( f(x, y) = e^{xy} \) given the constraint \( x^3 + y^3 = 16 \). (It turns out that \( f(x, y) \) does not achieve a minimum)
12. Find the extreme values (max and min) of \( f(x, y) = -x^2 - y^2 + 2x + 6y - 8 \) on the line segment in the \((x, y)\)-plane between the points \((2, 0)\) and \((2, 4)\). (Note: this is a problem you would face in finding the extreme values of \( f(x, y) \) over a region in the plane that has the given line segment as part of its boundary).