1. (14 points) Find and classify the critical points of
\[ f(x, y) = x^3 + y^3 + 3x^2 - 3y^2 - 8. \]

2. (14 points) Find an equation of the tangent plane to the surface \( \cos(\pi x) - x^2y = 4 - yz - e^{xz} \) at the point \((0,1,2)\).
3. (14 points) Evaluate the triple iterated integral

\[ \int_{0}^{3} \int_{0}^{\sqrt{9-y^2}} \int_{0}^{\sqrt{18-x^2-y^2}} (x^2 + y^2 + z^2) \, dz \, dx \, dy. \]

4. (14 points) Evaluate the double iterated integral

\[ \int_{-1}^{0} \int_{-\sqrt{1-y^2}}^{0} \frac{2}{1 + \sqrt{x^2 + y^2}} \, dx \, dy. \]
5. (14 points) Evaluate the iterated integral
\[ \int_0^3 \int_{y^2}^9 y \cos(x^2) \, dx \, dy. \]

6. (16 points)
(a) If \( w = w(x) \), and \( x = x(r, s, t) \). Write down a chain rule formula for \( \frac{\partial w}{\partial s} \).

(b) Find \( \text{curl} \ < xy, yz, xz > \).
7. (14 points) Use Green’s theorem to find the work done by the force field \( \vec{F}(x, y) = (y^2, x^2) \) in moving an object around the triangle with vertices \((0,0), (1,0), (0,1)\) one time in the counterclockwise direction.

8. (16 points) Given the force field \( \vec{F}(x, y, z) = \langle y^2 \cos(xy) - 3, \sin(xy) + 2y + xy \cos(xy), 2z \rangle \).
   
a. Find a potential function for this force field.

b. How much work is done by this force field in moving an object from \((2,-1,1)\) to \((1,3,0)\)?
9. (14 points) Find the flux of the vector field \( \vec{F}(x, y, z) = \langle -xz, -yz, z^2 \rangle \) up through the cone \( z = \sqrt{x^2 + y^2} \) for \( 0 \leq z \leq 4 \), oriented upward.

10. (14 points) A rectangular box without a lid is made from 12 square feet of cardboard. Use Lagrange multipliers to find the maximum volume of such a box.
11. (14 points) Given $f(x, y) = \sqrt{x^2 + y^2}$.
   a. Find the rate of change of $f$ at $(3,4)$ in the direction from the point $(3,4)$ to the point $(0,0)$.
   
   b. Find the maximum value of all of the directional derivatives of $f$ at $(3,4)$.
   
   c. Find a vector $\vec{w}$ such that the rate of change of $f$ at $(3,4)$ in the direction of $\vec{w}$ is zero.

12. (14 points) Find the quadratic approximation of $f(x, y) = 2 + 3x + 4y + x^2 - 2y^2$ near $x = 2, y = 1$. 
13. (14 points) Find the equation of the plane passing through the points (2,1,−3), (1,2,1), and (1,−2,4).

14. (14 points) Use Stoke’s theorem to evaluate the line integral $\int_C \vec{F} \cdot d\vec{r}$, where $\vec{F}(x,y,z) = <0, x^2, 0>$ and $C$ is the intersection of the plane $2x + y + z = 2$ with the coordinate planes traversed counterclockwise as viewed from above.