1. Find and sketch the domain of $f(x,y) = \sqrt{x^2+y^2-1} + \ln(4 - x^2 - y^2)$.

2. Draw a contour map for the function $f(x,y) = x^2 - y$. In particular, neatly draw and label the level curves $f(x,y) = k$ for $k = -1, 0, 1, 2$.

3. Find the limit, if it exists, or show that the limit does not exist.

(a). $\displaystyle\lim_{(x,y)\to(0,0)} \frac{xy+1}{x^2+y^2+1}$

(b). $\displaystyle\lim_{(x,y,z)\to(0,0,0)} \frac{x^2+2y^2+3z^2}{x^2+y^2+z^2}$

4. Given $f(x,y) = \begin{cases} \dfrac{3xy^2}{x^2+y^4} & \text{if } (x,y) \neq (0,0) \\ 0 & \text{if } (x,y) = (0,0), \end{cases}$ show that f is not continuous at (0,0).

5.

(a). Find the first partial derivatives of $g(x,y) = \dfrac{x}{x+2y}$.

(b). Find all second partial derivatives of $f(s,t) = \ln(3s^2 - t)^2$

(c). Use implicit differentiation to find $\partial z/\partial x$ for $xyz = \cos(xyz)$.

6. Given the surface $x^2+y^2+z^2-4y-2z+2 = 0$ and the surface represented by the graph of $f(x,y) = \frac{3}{2}x^2+y^2-\frac{1}{2}$.

(a). Determine whether the surfaces are tangent, normal, or neither at the point (1,1,2).

(b). Find the equation of the tangent plane to the surface $f(x,y) = \frac{3}{2}x^2 + y^2 - \frac{1}{2}$ at the point (1,1,2).

7. Find the linear approximation of the function $f(x,y) = e^x \cos xy$ at the point (0,0).

8. If $z = y + f(x^2 - y^2)$, where f is differentiable, show that $y\dfrac{\partial z}{\partial x} + x\dfrac{\partial z}{\partial y} = x$.

9. Find $\dfrac{\partial z}{\partial x}, \dfrac{\partial z}{\partial y}$ if the equation $\ln(x + yz) = 1 + xy^2 z$ implicitly defines $z = z(x,y)$.

10. Given $z = z(x, y)$ where $x = 2r + 3s$ and $y = r^2$, find $\dfrac{\partial^2 z}{\partial r^2}$

11. Write out the chain rule for $f = f(x, y, z)$, where $x = x(r, s), y = y(r, s), z = z(r, s)$

12. Find the directional derivative of $g(x, y) = \arctan(xy^2)$ at $(2, 1)$ in the direction of $\mathbf{v} = \langle 2, -3 \rangle$

13. Given $T(x, y, z) = 3x^2 + 4y^2 + 5z$ is the temperature at a point (x, y, z).

(a). How fast (in degrees per unit distance) is the temperature changing at the point P(1,-1,2) in the direction of Q(3,2,-4)?

(b). In which direction does the temperature increase the fastest at P?

14. Find the points on the hyperboloid $x^2 - y^2 + 2z^2 = 1$ where the normal line is parallel to the line that joins the points $(5, 3, 6)$ and $(8, 4, 10)$.

15. Given $f(x, y) = 1 - x^3 + 4xy - 2y^2$

(a). Find all the critical points of f. Determine if each critical point yields a relative maximum or minimum or a saddle point.

(b). Find the absolute maximum and minimum values of f on the set D defined as the closed triangular region in the xy-plane with vertices (0,0), (0,12), and (12,0).

16. Find the points on the surface $xy^2z^3 = 2$ that are closest to the origin. [Use both the "regular" method (Section 14.7) and the method of Lagrange Multipliers (Section 14.8).]

17. Use the method of Lagrange Multipliers to find the points on the cone $z^2 = x^2 + y^2$ that are closest to the point $(4, 2, 0)$.

18. Sketch the solid whose volume is given by the iterated integral $\displaystyle\int_0^1 \int_0^1 2 - x^2 - y^2 \, dy \, dx$.

19. Evaluate the following integrals

(a). $\displaystyle\int_0^1 \int_0^x \cos(x^2) \, dydx$

(b). $\displaystyle\iint_D y \, dA$ where D is the region in the first quadrant that lies above $y = \dfrac{1}{x}$ and $y = x$ and below the line $y = 2$.

20. Rewrite the integral using the indicated order of integration. (**Do NOT evaluate**):

(a). $\int_{-2}^{2}\int_{y^2}^{4} y\,dx\,dy$ Rewrite using $dy\,dx$

(b). $\int_{0}^{2}\int_{x^2}^{x+2} dy\,dx$ Rewrite using $dx\,dy$

21. Find the volume of the solid region in the 1st Octant bounded by the coordinate planes and the plane $2x + 3y + 4z = 12$.

22. Use a double integral and polar coordinates to find the volume of the solid above the cone $z = \sqrt{x^2 + y^2}$ and below the the sphere $x^2 + y^2 + z^2 = 1$. (**Set up the integral, but do NOT evaluate.**)