1. (10) Find the volume of the solid that lies above the paraboloid \( z = x^2 + y^2 \) and below the half-cone \( z = \sqrt{x^2 + y^2} \).

2. (10) Find the center of mass of the solid in problem 1, if the density is a constant \( d \).

3. (10) Find the mass of the ball given by the equation \( x^2 + y^2 + z^2 \leq a^2 \) if the density at the point \( (x, y, z) \) is equal to the distance from the origin.

4. (10) Evaluate the integral \( \int_0^1 \int_y^{2-y} e^{(x-y)/(x+y)} \, dx \, dy \) by means of the change of variables \( u = x - y, \, v = x + y \). (Hint: let \( R \) be the region of integration in terms of \( x-y \) coordinates. Find the image of this region in \( u-v \) coordinates under the change in variables.)

5. (15) a) Use the curl to show that the vector field

\[
\mathbf{F}(x, y, z) = yz e^{xy} \mathbf{i} + (zxe^{xy} + z \cos(y)) \mathbf{j} + (e^{xy} + \sin(y)) \mathbf{k}
\]

is conservative.

b) Find a potential function \( f(x, y, z) \) for \( \mathbf{F}(x, y, z) \) in a).

c) Use part b) to evaluate \( \int_C \mathbf{F} \cdot d\mathbf{r} \), where \( C \) is the straight-line segment from the point \((1, \pi, 1)\) to the point \((2, 2\pi, 2)\).

6. (10) Set up and evaluate the integral for the surface area of the parametrized surface \( S \) given by the equations

\[
x = u + v, \quad y = u - v, \quad z = 2u + 3v
\]

for \( 0 \leq u \leq 1 \) and \( 0 \leq v \leq 1 \). Describe this surface.
7. (10) Evaluate the line integral \( \oint_C y \, dx + (x^2 + y) \, dy \), where \( C \) is the boundary of the rectangle whose vertices are (2, 1), (5, 1), (5, 3), and (2, 3), with counter-clockwise orientation.

8. (10) A particle starts at the point (-2, 0), moves along the \( x \)-axis to the point (2, 0), and then along the semi-circle \( y = \sqrt{4 - x^2} \) to the starting point. Use Green's theorem to find the work done on this particle by the force field \( \mathbf{F}(x, y) = \langle x, x^3 + 3xy^2 \rangle \).

9. (10) What is the surface area of the part of the surface \( z = 1 + 3x + 2y^2 \) that lies above the triangle with vertices (0, 0), (0, 1), and (2, 1)? (Hint: choose the order in which you do the integration carefully.)

10. (15) Express the iterated volume integral \( V = \int_0^4 \int_0^{4-z} \int_{-\sqrt{y}}^{\sqrt{y}} 1 \, dx \, dy \, dz \) in the following three ways as an iterated integral. Sketch the solid whose volume is given by this integral.

   a) Using the order of integration \( dx \, dz \, dy \).

   b) Using \( dz \, dx \, dy \).

   c) Using \( dy \, dz \, dx \).