NAME: __________________________
CSU ID: __________________________

SECTION NUMBER: _____

You may NOT use calculators or any references. Show work to receive full credit.

GOOD LUCK !!!

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1. Consider the solid bounded below by the upper part of the hyperboloid $-x^2 - y^2 + z^2 = 1$ and above by the plane $z = 2$.

   (a) (8 pts) Set up the integral that computes the volume of this solid in rectangular coordinates with $dV = dz dy dx$. Please use exactly this order of integration. Do Not Evaluate.

   (b) (12 pts) Change the integral to cylindrical coordinates and then evaluate the resulting integral.

2. Consider the solid of revolution defined by $\rho = 1 + \cos \varphi$, in spherical coordinates, with density function $\delta(x, y, z) = \sqrt{x^2 + y^2 + z^2}$.

   (a) (10 pts) Set up a triple integral in spherical coordinates computing $M$, the mass of the solid. Do Not Evaluate.

   (b) (5 pts) Set up a triple integral in spherical coordinates representing $M_{xy}$. Do Not Evaluate.

   (c) (5 pts) Without doing any computations of triple integrals, give the values of $M_{xz}$ and $M_{yz}$. Justify your answer.

3. (15 pts) Sketch the area between the circles $(x + 1)^2 + y^2 = 1$ and $x^2 + y^2 = 1$, labeling appropriately. This area can be computed as the sum of two double integrals in polar coordinates. Write down this sum of double integrals. Do Not Evaluate.

4. Consider the integral $\int \int \int \int_{R} e^{(y-x)/(y+x)} dA$ where $R$ is the triangle with vertices $(0, 0), (2, 0), \text{ and } (0, 2)$.

   (a) (10 pts) Define the change of variables $u = y - x$ and $v = x + y$. Sketch the region $R$ in the $xy$ plane and the mapped region, $R'$ in the $uv$ plane. Label the vertices of $R'$ in the $uv$ plane.

   (b) (5 pts) Rewrite the integral in terms of the variables $u, v$. All limits of integration must be specified.

   (c) (5 pts) Evaluate the integral.

5. Consider the curve $C$ defined by $r(t) = ti + t^2j$, between the points $P = (-2, 4)$ and $Q = (1, 1)$.

   (a) (10 pts) Set up and evaluate the line integral that computes the work done in moving from $P$ to $Q$ along the curve $C$ in the force field $\mathbf{F} = \sqrt{y}i + \sqrt{9 - x^2}j$.

   (b) (10 pts) Consider the field

   $\mathbf{G} = \left( \pi y \cos(\pi xy) + \frac{x}{\sqrt{x^2 + 1}} \right) \mathbf{i} + (\pi x \cos(\pi xy) + e^y) \mathbf{j}$.

   Is there a potential function $\phi(x, y)$ for $\mathbf{G}$? If so, find the potential function. If not, give a reason why $\mathbf{G}$ does not have a potential function.

   (c) (5 pts) Find the work done in moving along the curve $C$ from $P$ to $Q$ in the force field $\mathbf{G}$ of part (b).