1. (10 points) Find the volume of the first-octant region outside the paraboloid $z = x^2 + y^2$ and inside the cylinder $x^2 + y^2 = 4$.

2. Set up the following integrals. **You need *not* evaluate the integrals, just set them up.**

(a) (8 points) $\int_0^1 \int_{e^x}^{e} xy\, dy\, dx$ rewritten as an iterated integral with the x-integration performed first.

(b) (8 points) $\iiint_\Omega z\, dx\, dy\, dz$ rewritten in spherical coordinates, where Ω is the region above the cone $z = \sqrt{\dfrac{x^2 + y^2}{3}}$ and inside the sphere $x^2 + y^2 + z^2 = 9$.

(c) (9 points) $\int_0^1 \int_x^{\sqrt{2-x^2}} \int_0^{x^2+y^2} \sqrt{x^2 + y^2}\, dz\, dy\, dx$ rewritten in cylindrical coordinates.

~~3. (10 points) Let $f : \mathbf{R}^3 \to \mathbf{R}$ be a differentiable function. Let $a = \frac{\partial f}{\partial x}(1,0,-2)$,~~ $b = \frac{\partial f}{\partial y}(1,0,-2)$, $c = \frac{\partial f}{\partial z}(1,0,-2)$. Let $g : \mathbf{R}^2 \to \mathbf{R}^3$ by $g(u,v) = (e^v + 2u, u + v, u - 2)$. Compute the derivative matrix $D(f \circ g)(0,0)$ in terms of a, b, and c.

4. (10 points) Prove that the path $\mathbf{c}(t) = (\cos t, \sin t, 0)$ is a flow line of the vector field $\mathbf{F}(x,y,z) = (-y, x, z^5)$. (Be sure to state carefully what it means for a path to be a flow line of a vector field.)

6. (10 points) Find an equation for the tangent plane at the point $(-2,1,-3)$ to the ellipsoid given by $\dfrac{x^2}{4} + y^2 + \dfrac{z^2}{9} = 3$.

7. (10 points) Evaluate the surface integral $\iint_{\partial W} \mathbf{F} \bullet d\mathbf{S}$, where $\mathbf{F}(x,y,z) = (1, 1, z(x^2 + y^2))$ and W is the solid cylinder given by $x^2 + y^2 \le 1$, $0 \le z \le 1$. [Hint: Do this the easy way!]

8. (10 points) Let H be the regular hexagon in the plane whose vertices are $(1,0)$, $\left(\frac{1}{2}, \frac{\sqrt{3}}{2}\right)$, $\left(-\frac{1}{2}, \frac{\sqrt{3}}{2}\right)$, $(-1,0)$, $\left(-\frac{1}{2}, -\frac{\sqrt{3}}{2}\right)$, $\left(\frac{1}{2}, -\frac{\sqrt{3}}{2}\right)$. Evaluate the line integral $\oint_{\partial H} \mathbf{F} \bullet d\mathbf{s}$, where $\mathbf{F}$ is the vector field $\mathbf{F}(x,y) = (\frac{y^2}{2}, xy + x)$. [Hint: Do this the easy way!]