1. *(20 pts)* We consider here the points $\vec{a} = (1,0,0), \vec{b} = (0,1,0), \vec{c} = (0,0,1), \vec{k} = (3,3,6)$. (A) Find the magnitude of the vector $\vec{d}$ represented by the arrow with tail at $\vec{a}$ and head at $\vec{k}$. (B) Find a vector $\vec{p}$ perpendicular to the plane P containing $\vec{a}$, $\vec{b}$, $\vec{c}$. (C) Find the equation of the plane Q that is parallel to P and contains $\vec{k}$. (D) Find $\vec{d} \cdot \vec{p}$ as part of a computation of the distance from $\vec{k}$ to P.

2. *(20 pts)* (A) Identify a standard curve of high school algebra and an explicit, ordered sequence of geometric transformations on it by which you can produce the surface S with equation $4x^2 + z^2 = e^{2y-3}$. (B) Cross sections of S parallel to one of the coordinate planes give ellipses; identify which coordinate plane this is.

3. *(20 pts)* (A) The surface S has equation $xe^y + y^2 z = z^3$. Find functions f, g, and h, along with their domains and targets, for which S is the graph, a level set, and an image (respectively). (B) Parametrize the curve that is the intersection of S with the cylinder $y^2 + z^2 = 9$.

4. *(20 pts)* T is a linear transformation from $\mathbb{R}^3$ to $\mathbb{R}^3$, and we know $T(1,4,2) = (3,2,5)$, $T(0,1,2) = (1,0,1)$, $T(0,0,1) = (1,1,1)$. (A) Find the matrix representing T. (B) Find the matrix representing $T \circ S$, where S reflects vectors through the plane $x = y$.

5. *(20 pts)* Compute *directly from the definition* the directional derivative $D_{\vec{v}} g(\vec{a})$, where $\vec{a} = \vec{0}$, $\vec{v} = (2,3)$, and $g : \mathbb{R}^2 \to \mathbb{R}^2$ is defined by $g(x,y) = (xe^y, y \sin x)$.