1. (24 pts.) Parametrize the following regions. Specify the ranges for the parameters.

(a) The straight line segment from \((2, -1, 3)\) to \((1, 0, -2)\).
(b) The plane in \(\mathbb{R}^3\) containing \((0, 0, 1)\), \((1, 0, 0)\), \((0, 1, 0)\).
(c) The unit sphere \(\{(x, y, z) \in \mathbb{R}^3: x^2 + y^2 + z^2 = 1\}\).
(d) The southern hemisphere of the unit sphere \(\{(x, y, z) \in \mathbb{R}^3: x^2 + y^2 + z^2 = 1, z \leq 0\}\).
(e) The part of the unit sphere contained in the positive orthant: \(\{(x, y, z) \in \mathbb{R}^3: x^2 + y^2 + z^2 = 1, x \geq 0, y \geq 0, z \geq 0\}\).
(f) The unit ball \(\{(x, y, z) \in \mathbb{R}^3: x^2 + y^2 + z^2 \leq 1\}\).
(g) The ball of diameter 4 centered at \((5, 3, -1)\).
(h) The graph of \(z = f(x, y)\) in \(\mathbb{R}^3\), where \(f: \mathbb{R}^2 \to \mathbb{R}\) is a continuous function.

2. (32 pts.) Evaluate the following integrals

(a) \(\int x \, dx + y \, dy + z \, dz\) along the segment \(\{(2 - t, t, -1 + t): 0 \leq t \leq 1\}\).
(b) \(\iint x \, dy \, dz + y \, dz \, dx + z \, dx \, dy\) through the cylinder \(\{(\cos \theta, \sin \theta, z): 0 \leq \theta \leq 2\pi, -2 \leq z \leq 2\}\).
(c) \(\iint x \, dy \, dz + y \, dz \, dx + z \, dx \, dy\) through the disk \(\{(\rho \cos \theta, \rho \sin \theta, 2): 0 \leq \rho \leq 1, 0 \leq \theta \leq 2\pi\}\).
(d) \(\iiint (x^2 + y^2) \, dx \, dy \, dz\) over the solid cylinder \(\{(\rho \cos \theta, \rho \sin \theta, z): 0 \leq \rho \leq 1, 0 \leq \theta \leq 2\pi, -2 \leq z \leq 2\}\).

3. (16 pts.) True/false questions. Circle your choice. Justification is not necessary.

In this question all functions are differentiable on \(\mathbb{R}^3\).

Lowercase functions are \(\mathbb{R}^3 \to \mathbb{R}\) and uppercase functions are \(\mathbb{R}^3 \to \mathbb{R}^3\).

T F (a) The integral of \(df\) around any circle is 0.
T F (b) The flux of the curl \(\nabla \times F\) through a sphere is 0.
T F (c) The integral of divergence \(\nabla \cdot F\) over a ball is 0.
T F (d) If \(\nabla \times F = 0\), then \(F\) is a gradient, i.e. \(F = \nabla f\) for some \(f\).
T F (e) If \(df = 0\), then \(f = 0\).
T F (f) \(\nabla \times (\nabla f) = 0\)
T F (g) \(\nabla \cdot (\nabla F) = 0\)
T F (h) \(\nabla \cdot (\nabla \times F) = 0\)