Name: __________________________

Please show all work and explain your answers. Sketch.

1. (20 pts.) Find the arc length of the helix \( \gamma(t) = (3\cos(t), 3\sin(t), 2t) \) between \((3, 0, 0)\) and \((0, 3, \pi)\). Sketch.

2. (20 pts.) Find the flux of \( F(x, y, z) = (3, x, z) \) through the surface \( x^2 + y^2 + z^2 = 4, z \leq 0 \). Sketch the surface and \( F \) at several points on the surface.

3. (20 pts.) Find the work done by the force field \( F(x, y, z) = (x + 1, y + 2, z + 3) \) in moving a particle from the origin to \((1, -1, 2)\). Does it matter along which path the particle is moved? Explain.

4. (20 pts.) Let \( F = (6xz^2, 2y^3, 6zx^2) \) and \( \omega = F \cdot dS \), where \( dS = (dy\,dz, dz\,dx, dx\,dy) \).
   
   (a) Compute \( d\omega \).
   
   (b) Use the general fundamental theorem of calculus to express the flux of \( F \) through the unit sphere as a density integral with respect to \( dx\,dy\,dz \). Evaluate this integral.

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\begin{array}{c|c|c|c|c|c|c}
1 & 2 & 3 & 4 & \text{total (80)} & \% \\
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