1. (15%) Evaluate $\int_C (\arctan x + y^2)dx + (e^y - x^2)dy$ where C is the path enclosing the annular region shown in the following figure.

2. (15%) If $\mathbf{F}(x, y, z) = M\mathbf{i} + N\mathbf{j} + P\mathbf{k}$ is a vector field and M, N, and P have continuous second partial derivatives, then $\text{div}(\textbf{curl } \mathbf{F}) = 0$.

3. (15%) Let R be the region bounded by the square with vertices $(4, 0)$, $(6, 2)$, $(4, 4)$, and $(2, 2)$. Evaluate the integral $\int_R \int (x + y)e^{x-y}dA$.

4. (15%) Find the volume of the solid region Q bounded below by the upper nappe of the cone $z^2 = x^2 + y^2$ and above by the sphere $z^2 + x^2 + y^2 = 9$.

5. (10%) Evaluate $\int_C \mathbf{F} \cdot d\mathbf{r}$, where C is a piecewise smooth curve from $(-1, 4)$ to $(1, 2)$ and $\mathbf{F}(x, y) = 2xy\mathbf{i} + (x^2 - y)\mathbf{j}$ as shown in the following figure.

6. (10%) Evaluate $\int_C \mathbf{F} \cdot d\mathbf{r}$, where C is represented by $\mathbf{r}(t) = 2\cos t\mathbf{i} + 2\sin t\mathbf{j}$, $0 \le t \le \pi/2$ and $\mathbf{F}(x, y) = 3x\mathbf{i} + 4y\mathbf{j}$.

7. (10%) Evaluate $\int_0^{\sqrt{\pi/2}} \int_x^{\sqrt{\pi/2}} \int_1^3 \sin(y^2)dzdydx$.

8. (10%) Find the surface area S of the portion of the hemisphere $f(x, y) = \sqrt{25 - x^2 - y^2}$ that lies above the region R bounded by the circle $x^2 + y^2 \le 9$.