1. Find the absolute maximum and minimum values of

$$f(x, y) = x^2 + 2xy + 3y^2$$

on the closed triangular region with vertices $(-1, 1)$, $(2, 1)$, and $(-1, -2)$.

2. Show that the line integral

$$\mathcal{I} = \int_{\mathcal{C}} 2x \ln z \; dx + 3y^2 z \; dy + \left(\frac{x^2}{z} + y^3 \right) \; dz$$

is independent of path and evaluate $\mathcal{I}$ where $\mathcal{C}$ runs from $(1,1,1)$ to $(2,1,2)$.

3. Evaluate the line integral

$$\mathcal{I} = \oint_{\mathcal{C}} -y \sec^2 x \;\; dx + \tan x \;\, dy$$

where $\mathcal{C}$ is the triangle with vertices $(0, 0)$, $(\pi/4, 0)$, and $(\pi/4, \pi/2)$.

4. Find the surface area of the portion of the surface $z = \sqrt{4 - x^2 - y^2}$ that lies inside the cylinder $(x-1)^2 + y^2 = 1$.

5. Find the flux $\left(\iint_S \mathbf{F} \bullet \mathbf{n}\, d\mathbf{S}\right)$ of the field

$$\mathbf{F} = z^2\mathbf{i} + x\mathbf{j} - 3z\mathbf{k}$$

outward through the surface cut from the parabolic cylinder $z = 4 - y^2$ by the planes $x = 0,\ x = 1$, and $z = 0$.

6. Using the Divergence Theorem find

$$\iint_S \mathbf{F} \bullet \mathbf{n} \, d\mathcal{S}$$

where

$$\mathbf{F} = e^{yz}\mathbf{i} + 6y\mathbf{j} + 4z^2\mathbf{k}$$

and S is bounded by the sphere $x^2 + y^2 + z^2 = 16.$