1. Solve the following problems:

   (a) Determine the flux of $\mathbf{F} = \langle xy^2z^2,\ x^2z^2,\ -xy^2 \rangle$ outward through the surface S made up of the portions of the six planes $x = 0$, $x = 1$, $y = 0$, $y = 1$, $z = 0$, $z = 1$, with $0 \le x, y, z \le 1$.

   (b) Calculate the flux of $\mathbf{F} = \langle x^3z,\ y^3z,\ 0 \rangle$ outward through the boundary of the solid region with $x^2+y^2 \le 4$ and $1 \le z \le 3$.

   (c) Find the flux of $\mathbf{F} = \langle xy^2,\ yz^2,\ x^2z \rangle$ through the surface of the unit sphere with outward orientation.

   (d) Find the flux of the curl $\iint_S (\nabla \times \mathbf{F}) \cdot \mathbf{n}\, d\sigma$, where $\mathbf{F}(x, y, z) = \langle -2y\cos(z),\ 2x,\ xe^y \rangle$ and S is the upper half of the sphere $x^2 + y^2 + z^2 = 9$ with outward orientation.

   (e) Compute the outward flux $\iint_S \mathbf{F} \cdot \mathbf{n}\, d\sigma$ where S is the surface of the "ice cream cone" (the portion of the cone $z = \sqrt{x^2 + y^2}$ that lies inside the sphere $x^2 + y^2 + z^2 = 1$ along with that portion of the sphere that lies above the cone), and $\mathbf{F}(x, y, z) = \langle x + 2y^2,\ 5y - 3xz,\ y^2 + 6z \rangle$.

   (f) Evaluate the line integral $\int_C \mathbf{F} \cdot d\mathbf{r}$ where $\mathbf{F}(x, y, z) = \langle x - y^2,\ y - z,\ z^2 + y \rangle$ and C is the rectangle with vertices $(0, 0, 4)$, $(2, 0, 0)$, $(2, 1, 0)$, and $(0, 1, 3)$ lying in the plane $x + 2y + z = 4$, oriented in the counterclockwise direction when viewed from above.

   (g) Find the circulation of the vector field $\mathbf{F} = \langle 2xy, x^2, y \rangle$ around the counterclockwise boundary of the portion of the surface $z = x^2y$ that lies above the plane region with $0 \le x \le 1$ and $0 \le y \le x$.

   (h) Compute the flux of $\mathbf{F} = \langle 3x^2y, xy^2, 8xy \rangle$ outward through the surface S made up of the portions of the five planes $x = 0$, $x = 1$, $y = 0$, $y = 1$, $z = 1$, with $0 \le x, y, z \le 1$.

   (i) Calculate the flux of $\mathbf{F} = \left\langle xy^2 + e^z,\ x^2y + e^{2z},\ \sqrt{x^2 + y^2} \right\rangle$ through the portion of the surface $z = 1 - x^2 - y^2$ that lies above the xy-plane, with upward orientation.

   (j) Evaluate the flux of $\mathbf{F} = \langle x^3 + 2xz^2,\ x^2y + 2yz^2,\ 4y^2z \rangle$ outward through the upper half of the sphere $x^2 + y^2 + z^2 = 5$.