Physics 22: Homework 2

The following problems encompass the topic of electric flux.

1. Consider a right-triangular prism in the backdrop of a coordinate system with x-, y-, and z-axes. As illustrated in Figure 1, the prism has side lengths $a = 30$ cm, $b = 40$ cm, $c = 50$ cm, and $d = 50$ cm. This prism is immersed in a uniform electric field, $\vec{E} = (200\ \mathrm{N/C})\,\hat{y}$.

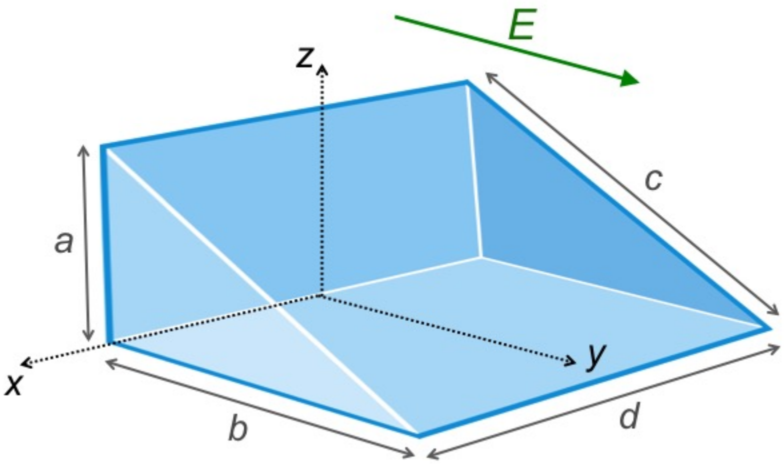

Figure 1: A right-triangular prism immersed in a uniform electric field. The electric field along the $+y$-direction, which happens to be parallel to the side-length b.

   (a) Determine the electric flux through each of the five faces.

   (b) Determine the net electric flux through the piece-wise smooth surfaces that comprise the prism.

2. Consider a hemispherical surface, of radius $R = 20$ cm, in the backdrop of a coordinate system with x-, y-, and z-axes. As illustrated in Figure 2, the hemispherical surface has its center of curvature at the origin of this coordinate system, with the surface defined for $x \in [-R, R]$, $y \in [-R, R]$, and $z \in [0, R]$. The hemispherical surface is immersed in a uniform electric field, $\vec{E} = (300\ \mathrm{N/C})\,\hat{z}$. Determine the electric flux through the hemispherical surface.

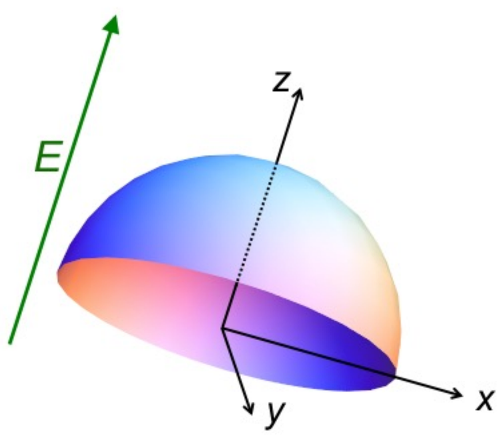

Figure 2: A hemisphere immersed in a uniform electric field. The z-axis acts as the hemisphere's axis of symmetry, running through its center of curvature and through its apex. The field is directed along this axis.

3. A point charge, $Q = -2.0$ nC, is placed at the center of a cube, of side-length $a = 60$ cm.

   (a) Determine the electric flux through any of the faces of the cube.

   (b) Determine the net electric flux through the piece-wise smooth surfaces that comprise the cube.

4. A rectangular sheet is placed in the xy-plane, with two of its edges coincident with the x- and y-axes themselves. As shown in Figure 3, the side along the x-axis has length a, while the side along the y-axis has length b. This sheet is immersed in a *nonuniform* electric field given by the formula,

$$\vec{E} = E_0 \frac{y}{b} \hat{z},$$

where E_0 is a constant (of course, with units of electric field). In other words, this electric field is directed uniformly along the $+z$-direction, but varies linearly along the y-direction. Specifically, it gets stronger as y increases from $y = 0$. However, note that at a fixed value of y, the field is constant as one moves purely along the x- or z-axes. Determine the electric flux through this rectangular sheet.

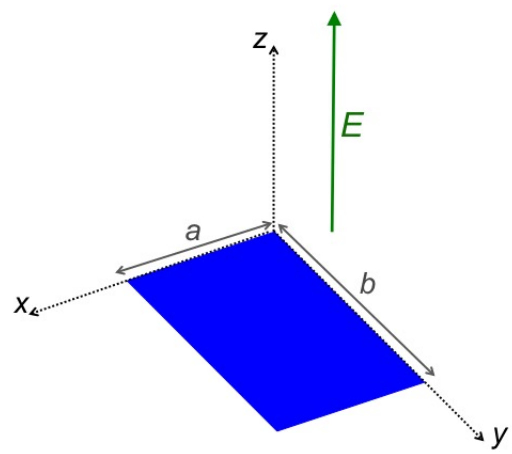

Figure 3: A rectangular sheet is on the xy-plane of a three-dimensional coordinate system with the z-axis perpendicular to the sheet. There is a nonuniform electric field direction along the z-direction that happens to be dependent on the y-position. The electric flux through this sheet is desired.