2.6: Continuity of the Potential Function

The potential function must be continuous at any point in space (with the exception noted below) since a discontinuous jump in its value would correspond to an unphysical infinite electric field strength:

$$E_r = -\frac{dV}{dr},$$

where E_r is the component of the electric field along the direction specified by dr. The exception referred to above occurs at a layer of dipoles; see the example problem discussed below. Let a surface carry a density of dipoles $\vec{P}_d$ per unit area (dimensions of Coulombs/m) oriented such that the dipole density is perpendicular to the plane. Such an electrical dipole layer, or **electrical double layer**, generates no external electric field, but it does generate a jump in potential given by

$$\Delta V = \left|\overrightarrow{\mathrm{P}}_d\right| / \epsilon_0. \tag{2.6.1}$$

Electrical double layers are common in nature. The potential difference that is observed to exist between the fluid inside a living cell and the surrounding fluid is maintained by an electrical double layer on the cell membrane. A double layer is also formed whenever a metal electrode is placed in an electrolytic solution. The potential difference across the double layer is called the **electrode potential**. The potential difference that is observed at the electrodes of a battery is the difference between the electrode potentials of two dissimilar conductors immersed in an electrolyte.