Answer on Question #79551, Physics / Electric Circuits

Question. State and explain the boundary condition for the displacement vector $\vec{D}$ at the boundary separating two dielectric media.

Answer. In a dielectric material, the presence of an electric field $\vec{E}$ causes the bound charges in the material (atomic nuclei and their electrons) to slightly separate, inducing a local electric dipole moment. The electric displacement field $\vec{D}$ is defined as

$$\vec{D} = \varepsilon_0 \vec{E} + \vec{P} = \varepsilon \varepsilon_0 \vec{E}$$

where: ε_0 is the vacuum permittivity (also called permittivity of free space), and $\vec{P}$ is the (macroscopic) density of the permanent and induced electric dipole moments in the material, called the polarization density.

The displacement field satisfies Gauss's law in a dielectric:

$$\nabla \cdot \vec{D} = \rho - \rho_b = \rho_f$$

At a boundary,

$$\left(\vec{D}_2 - \vec{D}_1\right) \cdot \vec{n} = D_{2n} - D_{1n} = \sigma_f$$

where σ_f is the free charge density on the surface and the unit normal $\vec{n}$ points in the direction from medium 1 to medium 2. If $\sigma_f = 0$ then

$$D_{1n} = D_{2n}.$$

The tangent components of the the displacement vector $\vec{D}$ at the boundary separating two dielectric media are discontinuous.