CLASSICAL ELECTRODYNAMICS II

Homework Set 3

October 2, 2015

1. A plane wave with electric field

$$\mathbf{E} = \mathbf{E}_0 \ \mathrm{e}^{i(kz-\omega t)}$$

is incident normally from vacuum onto a nonpermeable medium with an index of refraction n.

(a) Starting from the boundary conditions, determine the electric fields for the reflected and transmitted waves in terms of $\mathbf{E}_0$.

(b) Now suppose that linearly polarized light of the form $\mathbf{E}_0 = E_0\hat{x}$ is incident normally onto a nonpermeable medium that has index of refraction n_L for left-hand circularly polarized light and n_R for right-hand circularly polarized light. Use your results from part (a) to determine the cartesian components of the electric field of the reflected wave in terms of E_0, n_L, and n_R. Describe the polarization of the reflected wave.

(c) The reflection and transmission coefficients are respectively defined as:

$$R = \left| \frac{(\mathbf{S}'' \cdot \hat{z})}{(\mathbf{S} \cdot \hat{z})} \right| \qquad T = \left| \frac{(\mathbf{S}' \cdot \hat{z})}{(\mathbf{S} \cdot \hat{z})} \right| ,$$

where $\mathbf{S}$, $\mathbf{S}'$, and $\mathbf{S}''$ are the time-averaged Poynting vectors for the incident, refracted, and reflected waves, respectively. Determine the reflection coefficient for the case described in part (b).

2. A half-space with $z > 0$ is filled with a nonconducting medium having permeability μ', dielectric constant ϵ', and index of refraction

$$n' = \sqrt{\frac{\mu'\epsilon'}{\mu_0\epsilon_0}} .$$

The half-space with $z < 0$ is filled with a nonconducting medium having permeability μ, dielectric constant ϵ, and index of refraction

$$n = \sqrt{\frac{\mu\epsilon}{\mu_0\epsilon_0}} .$$

Consider a plane wave incident on the region with index of refraction n', with its polarization parallel to the plane of incidence as discussed in class. Calculate expressions for the transmission coefficient T and the reflection coefficient R for the case in which the polarization is parallel to the plane of incidence. Show explicitly that $T + R = 1$.