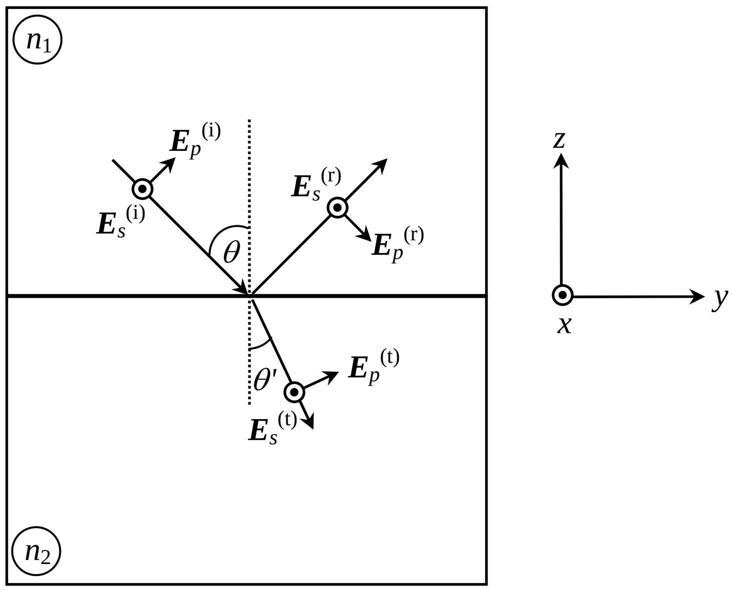
Fall 2011 Written Comprehensive Exam

Opti 501

<u>System of units: MKSA</u>

A monochromatic and homogeneous plane-wave of frequency ω_o arrives at an oblique angle θ at the interface between two dielectric media of refractive indices n_1 and n_2, as shown. (As usual, you may set the relative permeabilities μ_1 and μ_2 of the two media equal to 1.0. You may also assume that both n_1 and n_2 are real-valued, positive, and greater than or equal to unity.)



(4 pts) a) Write expressions for the E- and H-fields of the incident, reflected, and transmitted beams.

(2 pts) b) Derive the Fresnel reflection and transmission coefficients at the interface.

(2 pts) c) Under what circumstances will the reflection coefficient for the p-polarized beam vanish? You must base your argument on the expression obtained in part (b) for the Fresnel reflection coefficient. (**Hint**: This is the case of Brewster's incidence.)

(2 pts) d) Based on the reflection coefficients derived in part (b), specify the conditions for total internal reflection of both p- and s-polarized incident light at the interface.

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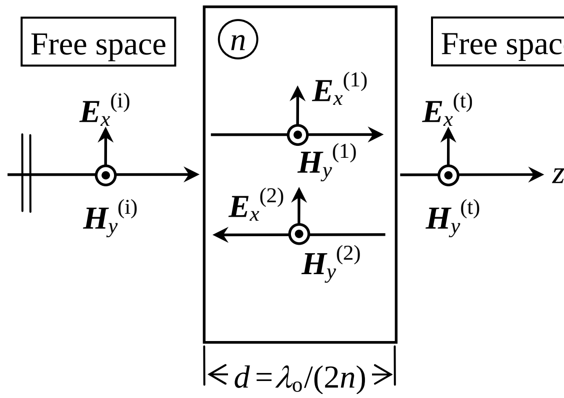
It is a well-known fact that, at normal incidence, the reflectivity of a transparent dielectric slab of refractive index n and thickness $d=\lambda_o/(2n)$ is precisely equal to zero; here $\lambda_o=2\pi c/\omega_o$ is the vacuum wavelength of the incident beam, which, as shown in the figure, is a homogeneous, monochromatic plane-wave of frequency ω_o. (You may assume that the incident beam is linearly polarized along the x-axis.)



(4 pt) a) Using the aforementioned fact, determine the E- and H-fields of the forward- and backward-propagating plane-waves inside the slab, as well as the E- and H-fields of the transmitted beam.

(4 pt) b) Determine the *time-averaged* Poynting vector inside the slab, and show that the rate of flow of optical energy per unit cross-sectional area inside the slab is the same as that of the incident beam, and also the same as that of the transmitted beam.

(2 pts) c) In what ways will the results obtained in parts (a) and (b) change, if the thickness d of the slab happens to be an integer-multiple of $\lambda_o/(2n)$, that is, if $d=m\lambda_o/(2n)$, where $m\neq 1$ is an arbitrary integer?