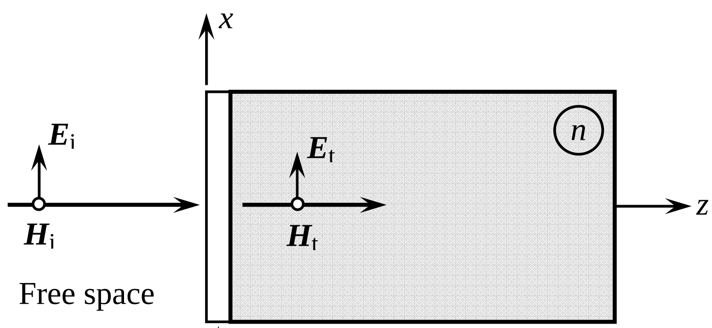
Opti 501 Prelim Questions, Fall 2008

1. A semi-infinite slab of transparent glass (refractive index = n) is coated with a *perfect* anti-reflection coating on its entrance facet. A monochromatic, linearly-polarized plane-wave arrives at the slab at normal incidence, as shown below. The incidence medium is free space, the vacuum wavelength of the light is λ_o, and the incident E-field is along the x-axis.

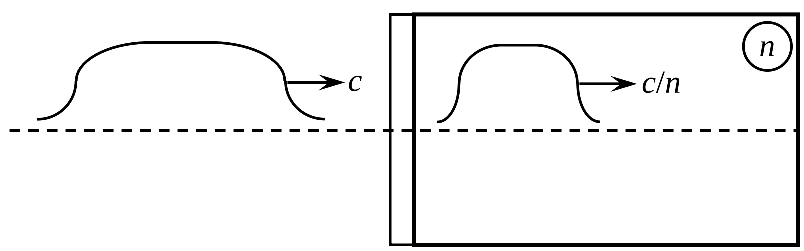
2 pts a) What is the relation between the incident E- and H-fields, E_i and H_i, in terms of the impedance of the free-space, $Z_o = \sqrt{\mu_o/\varepsilon_o}$?

2 pts b) What is the relation between the fields E_t, H_t transmitted into the slab in terms of Z_o and n?

3 pts c) Without making any assumptions about the structure of the anti-reflection coating, simply knowing that the optical energy of the beam passes entirely from the free space into the slab, determine the relation between the incident and transmitted E-fields E_i and E_t.



3 pts d) Assume now that, instead of a plane-wave, the incident beam is a pulse of light having the same central wavelength λ_o as before. Moreover, the front-facet coating is effective as a perfect anti-reflection coating for the entire pulse, and the semi-infinite slab is free from dispersion, so that, inside the slab, the pulse propagates with velocity c/n, as shown below. What are the E- and H-field energies inside the slab? Is the total E-field energy of the pulse equal to its total H-field energy? Is the pulse energy conserved before and after incidence?



2. Shown below is a collimated, monochromatic beam with a large, uniform cross-sectional area (essentially a finite-diameter plane-wave), incident on a semi-infinite, transparent medium of refractive index n. The angle of incidence is θ, the medium of incidence is free space, the footprint of the beam along the x-axis is ζ, and the incident beam is p-polarized (with the E- and H-field amplitudes being E_o and H_o, respectively). Denote the E-field amplitude of the reflected beam by ρE_o, that of the transmitted beam by τE_o.

2 pts a) In terms of ρ, τ, n, E_o, and the free-space impedance $Z_o = \sqrt{\mu_o/\varepsilon_o}$, what are the H-field amplitudes of the reflected and transmitted beams?

3 pts b) Determine the rate of flow of optical energy (per unit area per unit time) for the incident, reflected, and transmitted beams?

3 pts c) Use conservation of energy to find a relationship between ρ and τ in terms of n and θ.

2 pts d) How is the relation between ρ and τ obtained in part (c) affected if the incident beam happens to be s-polarized?