Quiz 14: The planar interface

Consider the following interface between two different dielectric media. An incoming monochromatic plane-wave, of frequency ω, at this interface has

$$\vec{k} = \begin{pmatrix} k_x \\ 0 \\ k_z \end{pmatrix}, \vec{E} = \begin{pmatrix} E_x \\ E_y \\ E_z \end{pmatrix}, \text{and } \vec{H} = \begin{pmatrix} H_x \\ H_y \\ H_z \end{pmatrix}$$

as its wave-vector, electric field vector, and magnetic field vector, respectively. The system is invariant in the y-direction.

1) Which components of $\vec{E}$, $\vec{H}$, and $\vec{k}$ are continuous at the interface? [3 points]
2) Due to y-invariance, the field can be separated into non-interacting TE and TM waves. Which components of $\vec{E}$ and $\vec{H}$ belong to TE and TM waves? [3 points]
3) The reflectivity at the planar interface between a substrate (ε_s, k_{sx}) and a cladding (ε_c, k_{cx}) for TE and TM polarized light is given as

$$\rho_{TE} = \frac{\left|k_{sx} - k_{cx}\right|^2}{\left|k_{sx} + k_{cx}\right|^2}, \quad \rho_{TM} = \frac{\left|k_{sx}\varepsilon_c - k_{cx}\varepsilon_s\right|^2}{\left|k_{sx}\varepsilon_c + k_{cx}\varepsilon_s\right|^2}$$

   The direction normal to the interface is along x. Show that the critical angle, for which total internal reflection occurs, is equal for TE and TM. [2 points]
4) Explain why the total internal reflection can only occur at interfaces with a particular relation between ε_s and ε_c, where light incidences from the substrate side. What is this relation and explain the underlying physics from the continuity of a particular component of the wave vector. [3 points]

These are your last 10 minutes of Thursday quizzes - you will miss it ;-)

Make sure that you indicate your name and seminar group on your answer sheet.