Spring 2013 Written Comprehensive Exam
Opti 501

System of units: MKSA

A linearly-polarized light pulse of duration T, frequency ω_0, E-field amplitude E_0, and cross-sectional area A, propagates in free space. (The pulse is long enough and broad enough that one can ignore its spectral content and treat it simply as a section from a plane wave.) The pulse arrives at normal incidence at the flat surface of a linear, isotropic, homogeneous, semi-infinite material of refractive index n, where n is real-valued and greater than unity. You may assume that the transparent dielectric material is non-magnetic [i.e., $\mu(\omega)=1$] and non-dispersive (i.e., n does *not* vary with frequency ω within the bandwidth of the light pulse).

2 pts a) What is the total energy content of the light pulse in free space?

3 pts b) Describe the properties of the reflected light pulse (e.g., frequency, wavelength, duration, polarization state, total optical power).

3 pts c) Find the E-field and H-field amplitudes of the light pulse that enters the glass medium. Describe the properties of the light pulse that propagates within the glass medium.

2 pts d) Show that the total energy of the pulse is conserved upon reflection/transmission at the glass surface.

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The classical theory of electrodynamics describes various relationships among fields and their sources. (Some of the fields are composite constructs in the sense that they are defined as combinations of fields and sources.) Maxwell's macroscopic equations govern the evolution of the fields in free space and in the presence of the sources.

1 pt a) Use a sentence or two to describe each source of the electromagnetic field in a qualitative way.

1 pt b) Give a brief description of each field that appears in Maxwell's equations.

2 pts c) Using Maxwell's equations, prove that free charge and free current densities satisfy the charge-current continuity equation.

3 pts d) Explain the notions of bound-charge and bound-current in the classical theory. Use the most general form of Maxwell's equations to derive expressions for the bound-charge and bound-current densities associated with polarization $\boldsymbol{P}(\boldsymbol{r},t)$ and magnetization $\boldsymbol{M}(\boldsymbol{r},t)$.

3 pts e) Show that bound-charge and bound-current densities satisfy the charge-current continuity equation.
