Physics 406: Electricity and Magnetism II

Problem Set #5: DUE Friday Oct. 19, 2012
Read: Griffiths Chap. 9.3-9.4

Problem 1: (10 points)

A plane wave solution to Maxwell's equations in a linear homogeneous dielectric is given

$$\mathbf{E}(z,t) = \mathbf{E}_0 \cos(\sqrt{6}\, z - 6\times 10^{10}\, t),$$

where t is in seconds, z is in centimeters, and $\mathbf{E}_0$ is a constant vector.

(a) What part of the electromagnetic spectrum is this wave (radio, microwave, x-ray, etc.)?
(b) What is the index of refraction of the medium?
(c) What would the wavelength be if this wave traveled in free space?
(d) Give an expression for the associated magnetic field.

Problem 2: Poynting's Theorem in Linear Dielectrics (10 points)

Derive the generalized Poynting Theorem for electromagnetic fields from Maxwell's equations in a *linear* dielectric:

$$\nabla \cdot \mathbf{S} + \frac{\partial U}{\partial t} = -\mathbf{J}_{free} \cdot \mathbf{E},$$

where $\mathbf{S} = \mathbf{E} \times \mathbf{H}$ is the Poynting vector and

$U = \frac{1}{2}(\mathbf{E}\cdot\mathbf{D} + \mathbf{B}\cdot\mathbf{H})$ is the total energy density in the electromagnetic field.

Note that the ohmic heating is due to the *free* current

Problem 3: Griffith Problem 9.17 (10 Points)