

## Physics 406

### Problem Set #5: DUE Thursday Oct. 19 2007

Read: Griffiths Chap. 9.3-9.4, Bekefi and Barrett Chap. 6.3-6.5, 7.1-7.4

#### 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.

- What part of the electromagnetic spectrum is this wave (radio, microwave, x-ray, etc.)?
- What is the index of refraction of the medium?
- What would the wavelength be if this wave traveled in free space?
- 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 *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

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

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

#### Problem 3: Griffith Problem 9.17 (10 Points)