ELECTROMAGNETIC ENGINEERING I

EE 4301

Spring 1998

Review Problem Set 1

1. Given the electric field

$$\mathbf{E}(\mathbf{r},t) = 10\cos[2\pi \times 10^9(t - z/c)]\hat{\mathbf{x}} \qquad \text{V/m} \tag{1}$$

where $c = 3 \times 10^8$ m/s, find the magnetic field $\mathbf{H}$ and the Poynting vector $\mathbf{S}$, assuming that all fields are in a medium in which $\epsilon = \epsilon_0$ and $\mu = \mu_0$.

2. Given the electric field

$$\mathbf{E}(\mathbf{r},t) = 20\cos(2\pi \times 10^9 t - kz)\hat{\mathbf{x}} \qquad \text{V/m} \tag{2}$$

find the magnetic field $\mathbf{H}$ using the differential form of Faraday's Law, assuming that all fields are in a medium in which $\epsilon_r = 2.10$ and $\mu_r = 1.0$. Also find the value of k that makes the given electric field and the magnetic field that you found satisfy all of Maxwell's equations. Use this value of k to find the wavelength. Also find the propagation velocity.

3. [1] An electric field in free space is given by

$$\mathbf{E}(\mathbf{r},t) = E_0 \sin(\alpha x)\cos(\omega t - kz)\,\hat{\mathbf{y}} \qquad \text{V/m} \tag{3}$$

Find the corresponding magnetic field from Faraday's Law. Under what condition(s) on α, β and γ do these fields satisfy Maxwell's equations?

4. [2] A 5 GHz uniform plane wave is propagating in a material characterized by $\epsilon_r = 2.53$, $\mu_r = 1$, and $\sigma = 0$. If the electric field is given by

$$\mathbf{E}(\mathbf{r},t) = 10\cos(\omega t - kz)\,\hat{\mathbf{x}} \qquad \text{V/m}, \tag{4}$$

determine

   (a) the velocity of propagation of electromagnetic waves,

   (b) the value of ω in Eq. (4),

   (c) the wavelength,

   (d) the value of k, and

   (e) the magnitude of the magnetic field that corresponds to the electric field in Eq. (4).

[1] C. R. Paul, *Electromagnetic Compatibility*, Problem 3.20

[2] Adapted from C. R. Paul, *Electromagnetic Compatibility*, Problem 3.27