

EE 3109 Applied Electromagnetics
Tutorial II

1. The instantaneous expression for the magnetic field intensity of a uniform plane wave propagating in the +y direction in air is given by

$$\mathbf{H} = 4 \times 10^{-6} \cos \left(10^7 \pi t - k_0 y + \frac{\pi}{4} \right) \hat{\mathbf{z}} \quad \text{A/m}$$

- (a) Determine k_0 and the location where H_z vanishes at $t = 3\text{ms}$.
- (b) Write the instantaneous expression for $\mathbf{E}$.
2. The magnetic field intensity of a linearly polarized uniform plane wave propagating in the +y direction in seawater ($\epsilon_r = 80$, $\mu_r = 1$ and $\sigma = 4\text{S/m}$) is

$$\mathbf{H} = 0.1 \sin \left(10^{10} \pi t - \frac{\pi}{3} \right) \hat{\mathbf{x}} \quad [\text{A/m}] \text{ at } y = 0.$$

- (a) Determine the attenuation constant, the phase constant, the intrinsic impedance, the phase velocity, the wavelength and the skin depth.
- (b) Find the location at which the amplitude of $\mathbf{H}$ is 0.01 A/m.
- (c) Write the expressions for $\mathbf{E}(y, t)$ and $\mathbf{H}(y, t)$ at $y = 0.5\text{m}$ as functions of t .
3. There is a continuing discussion on the radiation hazards to human health. The following calculations will provide a rough comparison.
- (a) The U.S. standard for personal safety in microwave environment is that the power density be less than 10mW/cm^2 . Calculate the corresponding standard in terms of electric field intensity and in terms of magnetic field intensity.
- (b) It is estimated that the earth receives radiant energy from the sun at a rate of about 1.3kW/cm^2 on a sunny day. Assuming a monochromatic plane wave (which is not), calculate the equivalent amplitudes of the electric and magnetic field intensity vectors.
4. From the point of view of electromagnetic, the power transmitted by a lossless coaxial cable can be considered in terms of the Poynting vector inside the dielectric medium between the inner conductor and the outer sheath. Assume that a d-c voltage V_0 causes a current I to flow to a load resistance, verify that the integration of the Poynting vector over the cross-sectional area of the dielectric medium equals the power $V_0 I$ that is transmitted to the load.

5. Airplanes use radar altimeters to determine their low-level altitude accurately. If an airplane is flying over the ocean ($\epsilon_r \cong 81$, $\mu \cong 1$ and $\sigma \cong 4S/m$) and the radar frequency is 7GHz, determine the percent reduction in received power due to the ocean.
6. A Doppler radar is used to determine the speed of a moving vehicle by measuring the frequency shift of the wave reflected from the vehicle.
 - (a) Assuming that the reflecting surface of the vehicle can be represented by a perfectly conducting plane and the transmitted signal is a time-harmonic uniform plane wave of a frequency f incident normally on the reflecting surface, find the relation between the frequency shift Δf and the speed u of the vehicle.
 - (b) Determine u both in (km/hr) and in (miles/hr) if $\Delta f = 2.33\text{kHz}$ with $f = 10.5\text{GHz}$.
7. For each uniform plane wave traveling in vacuum characterized below, describe the polarization and direction of propagation.
 - (a) $\mathbf{E} = \hat{\mathbf{x}}e^{+jkz}$
 - (b) $\mathbf{H} = (j\hat{\mathbf{x}} - \hat{\mathbf{y}})e^{-jkz}$
 - (c) $\mathbf{E} = (\hat{\mathbf{x}} + \sqrt{3}\hat{\mathbf{y}})e^{-jkz}$
 - (d) $\mathbf{E} = j(\hat{\mathbf{x}} + 2e^{\frac{j\pi}{2}}\hat{\mathbf{y}})e^{-jkz}$
8. Two x -polarized uniform plane waves of different strength are traveling in opposite directions and are superimposed:

$$\mathbf{E} = \hat{\mathbf{x}}(e^{-jkz} + ae^{jkz})$$

What average power (W/m^2) is associated with each wave considered separately (in the absence of the other), and what average power is associated with the combination?