

EE3109 Applied Electromagnetics
2024/25 Semester B
Week 3: Tutorial Questions

1. Write general expressions for the electric and magnetic fields of a 1 GHz sinusoidal plane wave traveling in the +y-direction in a lossless nonmagnetic medium with relative permittivity $\epsilon_r = 9$. The electric field is polarized along the x-direction, its peak value is 6 [V/m], and its intensity is 4 [V/m] at $t = 0$ and $y = 2$ [cm].
2. The magnetic field of a wave propagating through a certain nonmagnetic material is given by $\mathbf{H} = 30 \cos(10^8 t - 0.5y) \hat{\mathbf{z}}$ [A/m]. Find the following:
 - (a) The direction of wave propagation.
 - (b) The phase velocity.
 - (c) The wavelength in the material.
 - (d) The relative permittivity of the material.
 - (e) The electric field phasor.
3. The electric field phasor of a uniform plane wave is given by $\mathbf{E} = 10e^{j0.2z} \hat{\mathbf{y}}$ [V/m]. If the phase velocity of the wave is 1.5×10^8 [m/s] and the relative permeability of the medium is $\mu_r = 2.4$, find the following:
 - (a) The wavelength.
 - (b) The frequency f of the wave.
 - (c) The relative permittivity of the medium.
 - (d) The magnetic field $\mathbf{H}(z, t)$.
4. A wave radiated by a source in air is incident upon a soil surface, whereupon a part of the wave is transmitted into the soil medium. If the wavelength of the wave is 60 cm in air and 15 cm in the soil medium, what is the soil's relative permittivity?
5. The electric field of a plane wave propagating in a lossless, nonmagnetic, dielectric material with $\epsilon_r = 2.56$ is given by $\mathbf{E} = \hat{\mathbf{y}} 5 \cos(6\pi \times 10^9 t - kz)$ [V/m]. Assume the soil to be a very low-loss medium. Determine:
 - (a) f, u_p, λ, k and η
 - (b) The magnetic field $\mathbf{H}$
6. The magnetic field of a uniform plane wave propagating in a dielectric medium with $\epsilon_r = 36$ is given by $\mathbf{H} = 60(\hat{\mathbf{y}} + j\hat{\mathbf{z}})e^{-j\pi x/6}$ [mA/m]. Specify the modulus and direction of the electric field intensity at the $x = 0$ plane at $t = 0$ and 5 [ns].
7. A plane wave decays in a low-loss medium at a rate of 10 [Np/km].
 - (a) How far does it have to travel for the electric field to decay to 10% of its original value?
 - (b) Assume that the material has $\mu_r = 1$ and $\epsilon_r = 9$. What is the conductivity of the material?
8. For each of the following combinations of parameters, determine if the material is a low-loss dielectric, a quasi-conductor, or a good conductor, and then calculate: $\alpha, \beta, \lambda, u_p$ and η_c (complex characteristic impedance):
 - (a) Glass with $\mu_r = 1$, $\epsilon_r = 5$, and $\sigma = 10^{-12}$ S/m at 10 [GHz]
 - (b) Animal tissue with $\mu_r = 1$, $\epsilon_r = 12$, and $\sigma = 0.3$ S/m at 100 [MHz]
 - (c) Wood with $\mu_r = 1$, $\epsilon_r = 3$, and $\sigma = 10^{-4}$ S/m at 1 [kHz]
9. In a medium characterized by $\epsilon_r = 9$, $\mu_r = 1$, and $\sigma = 0.1$ [S/m], determine the phase angle by which the magnetic field leads the electric field at 100 [MHz].
10. Ignoring reflection at the air-water boundary, if the amplitude of a 1 GHz incident wave in air is 20 [V/m] at the water surface, at what depth will it be down to 1 [μ V/m]? Water has $\mu_r = 1$ and at 1 GHz, $\epsilon_r = 80$ and $\sigma = 1$ [S/m].
11. The electric field of a plane wave propagating in a nonmagnetic medium is given by $\mathbf{E} = 25e^{-30x} \cos(2\pi \times 10^9 t - 40x) \hat{\mathbf{z}}$ [V/m]. Obtain the corresponding expression for $\mathbf{H}$.