

EE3109 Applied Electromagnetics
2022/23 Semester B
Assignment 1

Questions 1-3 constitute Assignment 1A; Questions 4-7 constitute Assignment 1B.

1. Write Maxwell's Equations in differential form. Write within brackets the unit for each variable (eg. $\mathbf{E}$ [V/m]).
2. Show that the plane wave with magnetic field $\mathbf{H}^-(z, t) = H_0 \cos(\omega t + kz + \phi) \hat{\mathbf{x}}$ [mA/m] travels in the $-z$ -direction in free space with the speed of $v_p = \omega/k$. What is the electric field at the origin?
3. Given the time-domain electric field $\mathbf{E}(\mathbf{r}, t) = [A_1 \cos(\omega t - \beta_1 x + \phi_1) - A_2 \cos(\omega t - \beta_2 x + \phi_2)](\hat{\mathbf{z}} + \hat{\mathbf{y}})$ in free space, find the corresponding magnetic flux density
 - (a) In phasor form, and
 - (b) In time-varying form.
4. The magnetic field of a plane wave is $\mathbf{H}(\mathbf{r}, t) = 15 \cos(10^9 \pi t + mx + ny + 80^\circ) (\hat{\mathbf{x}} + 2\hat{\mathbf{y}})$ [A/m]. The wave travels in a lossless, nonmagnetic material with $\epsilon_r = 9$. Find:
 - (a) Its frequency
 - (b) Its wavelength
 - (c) Its propagation direction
 - (d) The constants m and n
 - (e) The corresponding $\mathbf{E}(\mathbf{r}, t)$.
 - (f) The amplitude of the $\mathbf{E}$ field at the origin, at time $t = 0$.
5. A 2.5 GHz left-hand circularly polarized plane wave travels in wet soil ($\epsilon_r = 9, \sigma = 5$ [S/m]). At $t = 0$ and at the origin ($z = 0$), the electric field is $\mathbf{E} = 2 \hat{\mathbf{y}}$ [V/m]. The plane wave travels in the $+z$ -direction.
 - (a) Is the soil a good dielectric, a good conductor or neither?
 - (b) What is the attenuation constant in [dB/m]?
 - (c) What is the complex permittivity?
 - (d) How fast does the wave travel in the soil?
 - (e) Write the magnetic field phasor.
 - (f) Draw the time evolution of the E-field at $z = 0$.
6. A 20 GHz right-hand circular polarized plane wave, travelling in air in the $-z$ -direction, has an electric field phasor $\mathbf{E} = 15$ [V/m] $\hat{\mathbf{x}}$ at time $t = 5$ ns and $z = 4.56$ m. Write its magnetic field as a function of time and space.
7. A plane wave propagates in free-space, in the z -direction, and has a magnetic field $\mathbf{H}(\mathbf{r}, t) = 7.0 \cos(\omega t - kz + 30^\circ) \hat{\mathbf{x}} + 3.5 \sin(\omega t - kz - 120^\circ) \hat{\mathbf{y}}$ [mA/m].
 - (a) Find its polarization state.
 - (b) Trace the time evolution of the magnetic field.
 - (c) Trace the time evolution of the electric field.
 - (d) Write the electric field as a summation of two circularly polarized plane waves (one LHC and one RHC). Which component is larger?