

ASSIGNMENT 1 - ELECTROMAGNETIC WAVES

EE23BTECH11054 - Sai Krishna Shanigarapu*

Question 8

Suppose that the electric field amplitude of an electromagnetic wave is $E_0 = 120\text{N/C}$ and that its frequency is $f = 50.0\text{ MHz}$.

- (a) Determine, B_0, ω, k and λ
 (b) Find expressions for \mathbf{E} and \mathbf{B}

Solution (a)

Electric field amplitude, $E_0 = 120\text{N/C}$

Frequency of source, $f = 50.0\text{ MHz} = 50 \times 10^6\text{Hz}$

Speed of light, $c = 3 \times 10^8\text{ m/s}$

Magnitude of magnetic field strength is given as:

$$B_0 = \frac{E_0}{c} = \frac{120}{3 \times 10^8} = 400\text{nT} \quad (1)$$

Angular frequency of source is given as:

$$\omega = 2\pi f = 3.14 \times 10^8 \text{rad/s} \quad (2)$$

Propagation constant is given as:

$$k = \frac{\omega}{c} = 1.05 \text{rad/m} \quad (3)$$

Wavelength of the wave is given as:

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{50 \times 10^6} = 6.0\text{m} \quad (4)$$

Solution (b)

Suppose the wave is propagating in the positive x direction. Then, the electric field vector will be in the positive y direction and the magnetic field vector will be in the positive z direction. This is because all three vectors are mutually perpendicular.

The standard basis vectors in Cartesian coordinates are denoted as e_1 (unit vector along the x-axis), e_2 (unit vector along the y-axis) and e_3 (unit vector along the z axis). The component of vectors \mathbf{E} and \mathbf{B} in terms of these basis vectors can be expressed as follows.

Equation of the Electric field vector is given as:

$$\mathbf{E} = E_0 \sin(kx - \omega t) e_2$$

$$\mathbf{E} = 120 \sin[1.05x - 3.1 \times 10^8 t] e_2$$

Magnetic field vector is given as:

$$\mathbf{B} = B_0 \sin(kx - \omega t) e_3$$

$$\mathbf{B} = (4 \times 10^{-7}) \sin(1.05x - 3.14 \times 10^8 t) e_3$$

Table 1 - input parameters

E_0	120 N/C
f	50.0 MHz
c	3×10^8

