

ANALOG NCERT 12.8.11

EE23BTECH11046 - Poluri Hemanth*

Question: Suppose that the electric field part of an electromagnetic wave in vacuum given as

$$\mathbf{E} = \{(3.1 \text{ N/C}) \cos[(1.8 \text{ rad/m})y + (5.4 \times 10^6 \text{ rad/s})t]\} \mathbf{e}_1$$

(a) What is the direction of propagation ?

(b) What is the wavelength ?

(c) What is the frequency ?

(d) What is the amplitude of the magnetic field part of the wave?

(e) Write an expression for the magnetic field part of the wave.

Solution:

Symbol	Values	Description
λ	$\frac{2\pi}{k}$	Wave length of E.M wave.
f	$0.859 \times 10^6 \text{ Hz}$	Frequency of E.M wave.
c	$3 \times 10^8 \text{ m/s}$	Velocity of propagation of E.M wave.
ω	$2\pi f$	Angular frequency of E.M wave.
k	1.8 rad/m	Wave number of E.M wave
B_o	$\frac{E_o}{c}$	Amplitude of magnetic part of E.M wave
E_o	3.1 N/C	Amplitude of electric part of E.M wave.
\mathbf{e}_1	-	Base vector in direction of electric field.
\mathbf{e}_2	-	Base vector in direction of propagation.
\mathbf{e}_3	-	Base vector in direction of magnetic field.

TABLE I

INPUT PARAMETERS

(a)

As the wave is in form of $\cos(ky + \omega t)$ the wave is propagating along $-y$ axis, represented by \mathbf{e}_2

(b)

$$k = \frac{2\pi}{\lambda} \quad (1)$$

$$\Rightarrow \lambda = \frac{2\pi}{1.8} \quad (2)$$

$$\approx 3.5 \text{ m} \quad (3)$$

(c)

$$\omega = 2\pi.f \quad (4)$$

$$5.4 \times 10^6 = 2\pi.f \quad (5)$$

$$\Rightarrow f = 0.859 \times 10^6 \text{ Hz} \quad (6)$$

(d)

$$B_o = \frac{E_o}{c} \quad (7)$$

where c is velocity of propagation of wave which is given by

$$c = \frac{\omega}{k} \quad (8)$$

$$= \frac{5.4 \times 10^6}{1.8} \quad (9)$$

$$= 3 \times 10^6. \quad (10)$$

$$B_o = \frac{3.1}{3 \times 10^6} \quad (11)$$

$$= 1.03 \times 10^{-6} \quad (12)$$

(e) Direction of magnetic field is \mathbf{e}_3 where,

$$\mathbf{e}_3 = \mathbf{e}_2 \times \mathbf{e}_1 \quad (13)$$

$$\mathbf{B} = B_o \cos(ky + \omega t) \mathbf{e}_3 \quad (14)$$

From (12)

$$\mathbf{B} = 1.03 \times 10^{-6} T \{ \cos[(1.8 \text{ rad/m})y + (5.4 \times 10^6 \text{ rad/s})t] \} \mathbf{e}_3 \quad (15)$$

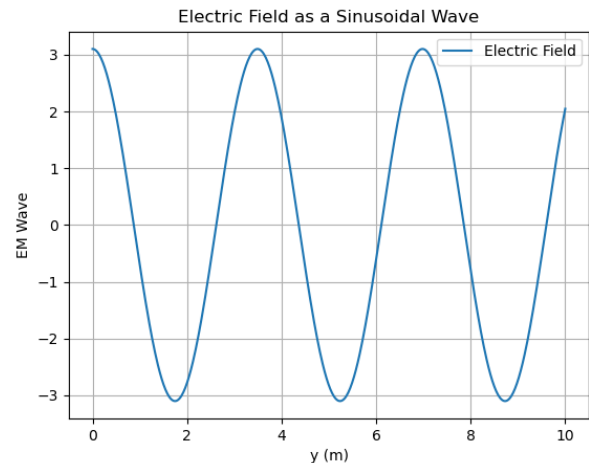


Fig. 1. Electric field part

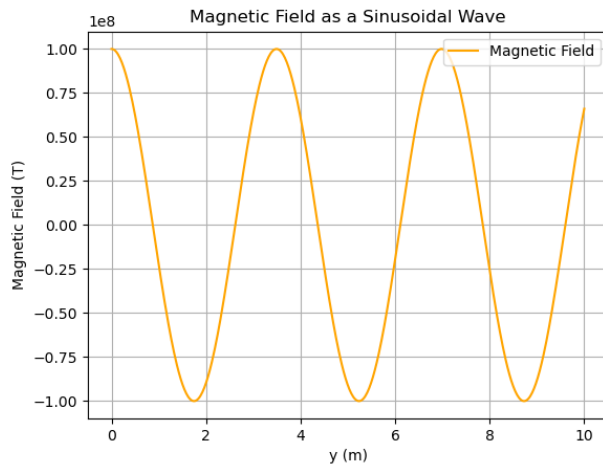


Fig. 2. Magnetic field part