ANALOG NCERT 12.8.11

EE23BTECH11046 - Poluri Hemanth*

Question: Suppose that the electric field part of an electromagnetic wave in vacuum given as
$\mathbf{E}$ ={(3.1N/C)cos[(1.8 rad/m)y+(5.4×10^{6}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	$0.859\times10^6 Hz$	Frequency of E.M wave.
c	$3\times10^6 m/s$	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 $cos(ky+wt)$ the wave is propagating along $-y$ axis, represented by $\mathbf{e_2}$
(b)

$$k = \frac{2\pi}{\lambda} \tag{1}$$
$$\Rightarrow \lambda = \frac{2\pi}{1.8} \tag{2}$$
$$\approx 3.5m \tag{3}$$

(c)

$$\omega = 2\pi.f \tag{4}$$
$$5.4x10^6 = 2.\pi.f \tag{5}$$
$$\Rightarrow f = 0.859\times10^6 Hz \tag{6}$$

(d)

$$B_o = \frac{E_o}{c} \tag{7}$$

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

$$c = \frac{\omega}{k} \tag{8}$$
$$= \frac{5.4\times10^6}{1.8} \tag{9}$$
$$= 3\times10^6. \tag{10}$$
$$B_o = \frac{3.1}{3\times10^6} \tag{11}$$
$$= 1.03\times10^{-6} \tag{12}$$

(e) Direction of magnetic field is $\mathbf{e_3}$
where,

$$\mathbf{e_3} = \mathbf{e_2}\times\mathbf{e_1} \tag{13}$$
$$\mathbf{B} = B_o cos(ky+wt)\mathbf{e_3} \tag{14}$$

From (12)

$$\mathbf{B} = 1.03\times10^{-6}T\{cos[(1.8rad/m)y + (5.4x10^6 rad/s)t]\}\mathbf{e_3} \tag{15}$$

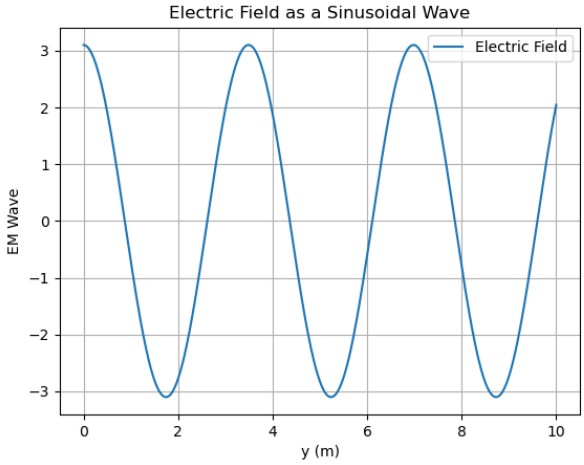

Fig. 1. Electric field part

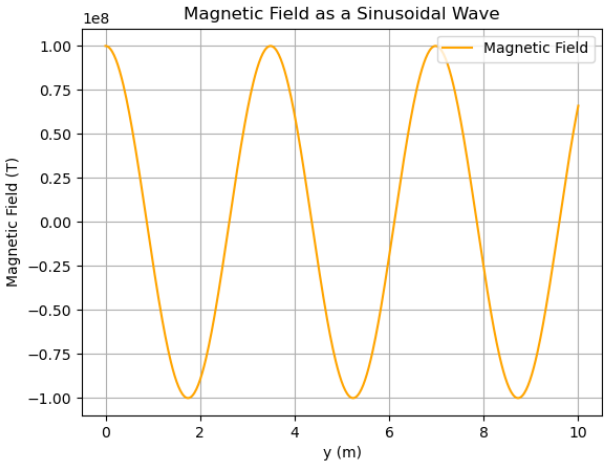

Fig. 2. Magnetic field part