**Question 8.5:**

A radio can tune in to any station in the 7.5 MHz to 12 MHz band. What is the corresponding wavelength band?

Answer

A radio can tune to minimum frequency, $\nu_1$ = 7.5 MHz= 7.5 × $10^6$ Hz

Maximum frequency, $\nu_2$ = 12 MHz = 12 × $10^6$ Hz

Speed of light, $c$ = 3 × $10^8$ m/s

Corresponding wavelength for $\nu_1$ can be calculated as:

$$\lambda_1 = \frac{c}{\nu_1}$$

$$= \frac{3\times10^8}{7.5\times10^6} = 40 \text{ m}$$

Corresponding wavelength for $\nu_2$ can be calculated as:

$$\lambda_2 = \frac{c}{\nu_2}$$

$$= \frac{3\times10^8}{12\times10^6} = 25 \text{ m}$$

Thus, the wavelength band of the radio is 40 m to 25 m.

**Question 8.6:**

A charged particle oscillates about its mean equilibrium position with a frequency of $10^9$ Hz. What is the frequency of the electromagnetic waves produced by the oscillator?

Answer

The frequency of an electromagnetic wave produced by the oscillator is the same as that of a charged particle oscillating about its mean position i.e., $10^9$ Hz.

**Question 8.7:**

The amplitude of the magnetic field part of a harmonic electromagnetic wave in vacuum is $B_0$ = 510 nT. What is the amplitude of the electric field part of the wave?

Answer

Amplitude of magnetic field of an electromagnetic wave in a vacuum,

$B_0$ = 510 nT = 510 × $10^{-9}$ T

Speed of light in a vacuum, $c$ = 3 × $10^8$ m/s

Amplitude of electric field of the electromagnetic wave is given by the relation,

$E = cB_0$

= 3 × $10^8$ × 510 × $10^{-9}$ = 153 N/C

Therefore, the electric field part of the wave is 153 N/C.

**Question 8.8:**

Suppose that the electric field amplitude of an electromagnetic wave is $E_0$ = 120 N/C and that its frequency is $v$ = 50.0 MHz. (a) Determine, $B_0$, ω, $k$, and λ. (b) Find expressions for **E** and **B**.

Answer

Electric field amplitude, $E_0$ = 120 N/C

Frequency of source, $v$ = 50.0 MHz = 50 × $10^6$ Hz

Speed of light, $c$ = 3 × $10^8$ m/s

**(a)** Magnitude of magnetic field strength is given as:

$$B_0 = \frac{E_0}{c}$$
$$= \frac{120}{3\times10^8}$$
$$= 4 \times 10^{-7}\ \text{T} = 400\ \text{nT}$$

Angular frequency of source is given as:

$\omega = 2nv$

= 2n × 50 × $10^6$

= 3.14 × $10^8$ rad/s

Propagation constant is given as:

$$k = \frac{\omega}{c}$$
$$= \frac{3.14\times10^8}{3\times10^8} = 1.05\ \text{rad/m}$$

Wavelength of wave is given as:

$$\lambda = \frac{c}{v}$$
$$= \frac{3\times10^8}{50\times10^6} = 6.0\ \text{m}$$

**(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.

Equation of electric field vector is given as:

$$\vec{E} = E_0 \sin(kx - \omega t)\hat{j}$$
$$= 120 \sin\left[1.05x - 3.14\times10^8 t\right]\hat{j}$$

And, magnetic field vector is given as:

$$\vec{B} = B_0 \sin(kx - \omega t)\hat{k}$$
$$\vec{B} = \left(4\times10^{-7}\right)\sin\left[1.05x - 3.14\times10^8 t\right]\hat{k}$$

**Question 8.9:**

The terminology of different parts of the electromagnetic spectrum is given in the text. Use the formula $E = hv$ (for energy of a quantum of radiation: photon) and obtain the photon energy in units of eV for different parts of the electromagnetic spectrum. In what way are the different scales of photon energies that you obtain related to the sources of electromagnetic radiation?

Answer

Energy of a photon is given as:

$$E = h\nu = \frac{hc}{\lambda}$$

Where,

$h$ = Planck's constant = $6.6 \times 10^{-34}$ Js

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

$\lambda$ = Wavelength of radiation

$$\therefore E = \frac{6.6\times10^{-34}\times3\times10^{8}}{\lambda} = \frac{19.8\times10^{-26}}{\lambda}\ \text{J}$$

$$= \frac{19.8\times10^{-26}}{\lambda\times1.6\times10^{-19}} = \frac{12.375\times10^{-7}}{\lambda}\ \text{eV}$$

The given table lists the photon energies for different parts of an electromagnetic spectrum for different $\lambda$.

| $\lambda$ (m) | $10^{3}$ | 1 | $10^{-3}$ | $10^{-6}$ | $10^{-8}$ | $10^{-10}$ | $10^{-12}$ |
|---|---|---|---|---|---|---|---|
| $E$ (eV) | $12.375 \times 10^{-10}$ | $12.375 \times 10^{-7}$ | $12.375 \times 10^{-4}$ | $12.375 \times 10^{-1}$ | $12.375 \times 10^{1}$ | $12.375 \times 10^{3}$ | $12.375 \times 10^{5}$ |

The photon energies for the different parts of the spectrum of a source indicate the spacing of the relevant energy levels of the source.

**Question 8.10:**

In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of $2.0 \times 10^{10}$ Hz and amplitude 48 V $m^{-1}$.

**(a)** What is the wavelength of the wave?

**(b)** What is the amplitude of the oscillating magnetic field?

**(c)** Show that the average energy density of the **E** field equals the average energy density of the **B** field. [$c = 3 \times 10^{8}$ m $s^{-1}$.]

********** END **********