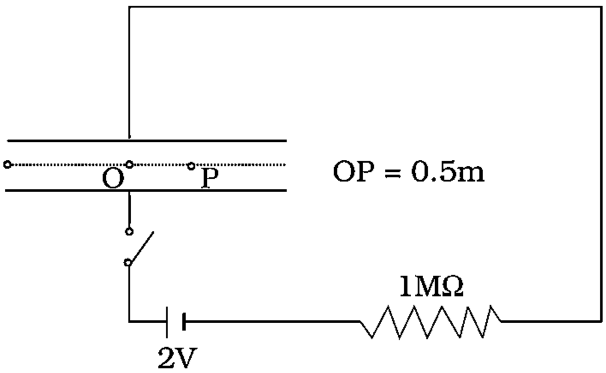
Examples

8.1: A parallel plate capacitor with circular plates of the radius $1\ m$ has a capacitance of $1\ nF$. At $t=0$, it is connected for charging in series with a resistor $R = 1\ M\Omega$ across a $2V$ battery $(Fig.\ 8.3)$. Calculate the magnetic field at a point P, halfway between the center and the periphery of the plates, after $t = 10^{-3}\ s$. (The charge on the capacitor at a time t is $q\ (t) = CV\ [1 - exp\ (-t/\tau\ )]$, where the time constant τ is equal to CR.)



Solution: The CR circuit's time constant is $\tau = CR = 10-3\ s$. Then, we have

$$q(t) = CV\ [1 - exp\ (-t/\tau)]$$

$$= 2 \times 10-9\ [1- exp\ (-t/10-3)]$$

At the time t, the electric field between the plates is

$$E = \frac{q(t)}{\varepsilon_0 A} = \frac{q}{\pi\varepsilon_0} : A = \pi(1)^2\ \mathrm{m}^2 = \text{area of the plates.}$$

Consider a circular loop with a radius of $(1/2)m$ that passes through P parallel to the plates. The magnetic field B at all points on the loop is the same value and runs the length of the loop. The flux ΦE through this loop is

$$\Phi E = E \times \text{an area of the loop}$$

$$= E \times \pi \times \left(\frac{1}{2}\right)^2 = \frac{\pi E}{4} = \frac{q}{4\varepsilon_0}$$

The displacement current at $t = 10^{-3} s$ is:

$$t_d = \varepsilon_0 \frac{d\Phi_x}{dt} = \frac{1}{4}\frac{dq}{dt} = 0.5 \times 10^{-6} \exp(-1)$$

Applying the Ampere-Maxwell law to the loop now yields,

$$B \times 2\pi \times \left(\frac{1}{2}\right) = \mu_0 \left(t_c + t_d\right) = \mu_0 \left(0 + t_d\right) = 0.5 \times 10^{-8} \mu_0 \exp(-1)$$

or, $B = 0.74 \times 10^{-13}\ \mathrm{T}$

8.2: A plane electromagnetic wave of frequency $25\ MHz$ travels in free space along the $x-$ direction. At a particular point in space and time, $E\ =\ 6.3\ \hat{}j\ V/m$. What is B at this point?

Solution: The magnitude of B is calculated using Eq. (8.10) is

$$B = \frac{E}{c}$$

$$= \frac{6.3\,\mathrm{V/m}}{3 \times 10^{5}\ \mathrm{m/s}}$$

$$= 2.1 \times 10^{-5}\ \mathrm{T}$$

We may determine the direction by noting that E is along the y-axis and the wave propagates along the $x - axis$.

Therefore, B should be in a direction perpendicular to both $x-\ and\ y-axes$. Using vector algebra, $E\ \times\ B$ should be along $x-$direction.

Since, $\left(+\ \hat{}j\right)\ \times\ \left(+k\hat{}\ \right)\ =\ \hat{}i$, B is along the z-direction.

Thus, $B\ =\ 2.1\ \times\ 10-8\ k\hat{}\ T$

8.3: The magnetic field in a plane electromagnetic wave is given by $B_y\ =\ \left(2\ \times\ 10^{-7}\right)\ T\ sin\ \left(0.5 \times 10^{3}\ x + 1.5 \times 10^{11} t\right)$.

(a) What is the wavelength and frequency of the wave?

Solution: Taking the given equation and comparing it to

$$B_y = B_0 \sin\left[2\pi\left(\frac{x}{\lambda} + \frac{t}{T}\right)\right]$$

We get, $\lambda = \dfrac{2\pi}{0.5 \times 10^{3}}\mathrm{m} = 1.26\,\mathrm{cm}$, and

$$\frac{1}{T} = v = \left(1.5 \times 10^{11}\right)/2\pi = 23.9\mathrm{GHz}$$

(b) Write an expression for the electric field.

Solution: $E_0 = B_0 c = 2\times10^{-7}\,\mathrm{T}\times3\times10^{8}\,\mathrm{m/s} = 6\times10^{1}\,\mathrm{V/m}$

The electric field component is perpendicular to both the propagation and magnetic field directions. As a result, the component of the electric field along the z-axis is calculated as

$E_x = 60\sin\left(0.5\times10^{3}x + 1.5\times10^{11}\ \mathrm{t}\right)\,\mathrm{V/m}$

8.4: Light with an energy flux of $18\ W/cm^2$ falls on a nonreflecting surface at normal incidence. If the surface has an area of $20\ cm^2$, find the average force exerted on the surface during a 30 minute time span.

Solution: The total amount of energy that falls on the surface is

$$U = \left(18\,\mathrm{W/cm^2}\right)\times\left(20\,\mathrm{cm^2}\right)\times(30\times60\,\mathrm{s})$$
$$= 6.48\times10^{5}\,\mathrm{J}$$

As a result, the total delivered momentum (for complete absorption) is

$$p = \frac{U}{c} = \frac{6.48\times10^{-3}\,\mathrm{J}}{3\times10^{\mathrm{E}}\,\mathrm{m/s}} = 2.16\times10^{-3}\,\mathrm{kg\,m/s}$$

An average force is applied to the surface

$$F = \frac{p}{t} = \frac{2.16\times10^{-3}}{0.18\times10^{4}} = 1.2\times10^{-1}\,\mathrm{N}$$

8.5: 5 Calculate the electric and magnetic fields produced by the radiation coming from a $100\ W$ bulb at a distance of $3\ m$. Assume that the efficiency of the bulb is 2.5% and it is a point source.

Solution: As a point source, the bulb emits light uniformly in all directions.

The surface area of the surrounding sphere is at a distance of $3m$ is:

$A = 4\pi r^2 = 4\pi(3)^2 = 113\,\mathrm{m^2}$

At this distance, the intensity I is

$$I = \frac{\text{Power}}{\text{Area}} = \frac{100\,\mathrm{W}\times2.5\%6}{113\,\mathrm{m^2}}$$
$$= 0.022\,\mathrm{W/m^2}$$

The electric field provides half of this intensity, while the magnetic field provides the other half.

$$\frac{1}{2} I = \frac{1}{2}\left(\varepsilon_0 E_{\max^2} c\right)$$

$$= \frac{1}{2}\left(0.022\,\mathrm{W/m^2}\right)$$

$$E_{\mathrm{rms}} = \sqrt{\frac{0.022}{\left(8.85\times10^{-12}\right)\left(3\times10^{\mathrm{K}}\right)}}\,\mathrm{V/m}$$

$$= 2.9\,\mathrm{V/m}$$

The root mean square value of the electric field is the value of E obtained above.
The peak electric field, E_0, in a light beam is sinusoidal because the electric field is sinusoidal is:

$$E_0 = \sqrt{2} E_{\mathrm{mix}} = \sqrt{2}\times 2.9\,\mathrm{V/m}$$

$$= 4.07\,\mathrm{V/m}$$

As a result, you can observe that the electric field strength of the light you use to read is quite strong. When compared to the electric field intensity of TV or FM waves, which is on the order of a few m icrovolts per meter, this is a significant difference.
Let's compute the magnetic field's strength now. It is

$$B_{rms} = \frac{E_{\mathrm{rms}}}{c} = \frac{2.9\mathrm{Vm}^{-1}}{3\times10^{8}\,\mathrm{m\,s}^{-1}} = 9.6\times10^{-9}\,\mathrm{T}$$

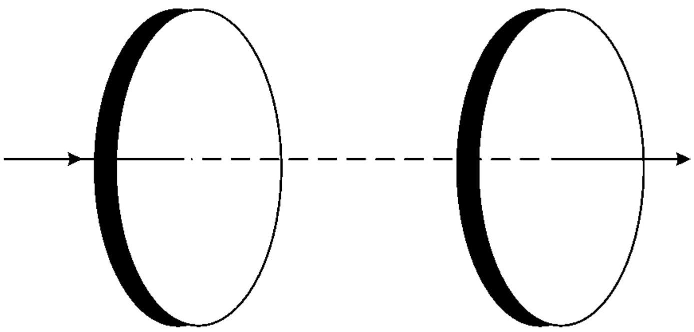
The peak magnetic field in the light beam is sinusoidal because the magnetic field in the light beam is sinusoidal.

$$B_0 = \sqrt{2} B_{rms} = 1.4\times10^{-8}\,\mathrm{T}$$

It's worth noting that, even though
the magnetic field's energy is equal to that of the electric field, the magnetic field's strength is low.

Exercises

8.1: Figure shows a capacitor made of two circular plates each of radius $12\,\text{cm}$, and separated by $5.0\,\text{cm}$. The capacitor is being charged by an external source (not shown in the figure). The charging current is constant and equal to $0.15\,\text{A}$.



(a) Calculate the capacitance and the rate of charge of potential difference between the plates.

Answer:

The radius of each circular plate, $\mathrm{r}=12\,\mathrm{cm}=0.12\,\mathrm{m}$

Distance between the plates, $d=5\,\mathrm{cm}=0.05\,\mathrm{m}$

Charging current, $I = 0.15\,A$

Permittivity of free space, $\varepsilon_0=8.85\times10^{-12}\,\mathrm{C}^2\,\mathrm{N}^{-1}\,\mathrm{m}^{-2}$

Capacitance between the two plates is, $\mathrm{C}=\dfrac{\varepsilon_0\,\mathrm{A}}{d}$

Where,

$\mathrm{A} =$ Area of each plate $=\pi r^2$

$$C=\frac{\varepsilon_0 \pi r^2}{d}$$

$$=\frac{8.85\times10\pi^{-12}\times(0.1\mathrm{A})^2}{0.05}$$

$$=8.0032\times10^{-12}\,\mathrm{F}$$

$$=80.032\mathrm{pF}$$

Charge on each plate, $q=CV$

Where,

$V =$ Potential difference across the plates

When both sides are differentiated with regards to time (t), the result is:

$$\frac{dq}{dt}=C\frac{dV}{dt}$$

But, $\frac{dq}{dt}=\text{current }(I)$

$$\therefore \frac{dV}{dt}=\frac{I}{C}$$

$$\Rightarrow \frac{0.15}{80.032\times10^{-12}}=1.87\times10^{9}\ \mathrm{V/s}$$

As a result, the potential difference between the plates changes is $1.87\times10^{9}\ \mathrm{V/s}$.

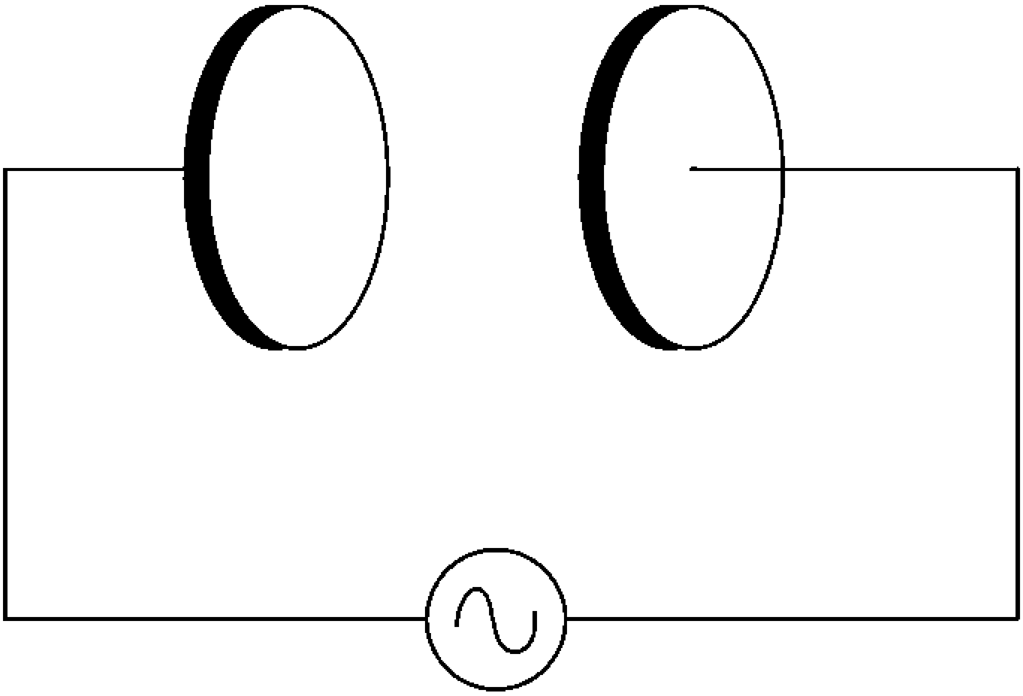
(b) Obtain the displacement current across the plates.

Answer: The conduction current is the same as the displacement current across the plates. Hence, the displacement current, $i\{d\}$ is $0.15\,\mathrm{A}$.

(c) Is Kirchhoff's first rule (junction rule) valid at each plate of the capacitor? Explain.

Answer: Yes. If we compute current using the sum of conduction and displacement, Kirchhoff's first rule remains true for each capacitor plate.

8.2: A parallel plate capacitor made of circular plates each of radius $\mathrm{R}=6.0\mathrm{cm}$ has a capacitance $\mathrm{C}=100\mathrm{pF}$. The capacitor is connected to a $230\,\mathrm{V}$ ac supply with a (angular) frequency of $300\mathrm{rad\ s}^{-1}$.



(a) What is the rms value of the conduction current?

Answer: Radius of each circular plate, $R = 6.0\,\text{cm} = 0.06\,\text{m}$

Capacitance of a parallel plate capacitor, $\mathrm{C} = 100\,\mathrm{pF} = 100 \times 10^{-12}\,\mathrm{F}$

Supply voltage, $\mathrm{V} = 230\,\mathrm{V}$

Angular frequency, $\omega = 300\,\mathrm{rad\,s^{-1}}$

Rms value of conduction current $I = \dfrac{V}{X_c}$

Where,

$\mathrm{X_C} =$ Capacitive reactance

$= \dfrac{1}{\omega C}$

$\therefore \mathrm{I} = \mathrm{V} \times \omega \mathrm{C}$

$= 230 \times 300 \times 100 \times 10^{-12}$

$= 6.9 \times 10^{-6}\,\mathrm{A}$

$= 6.9\,\mu\mathrm{A}$

As a result, the conduction current's rms value is $6.9\,\mu\mathrm{A}$.

(b) Is the conduction current equal to the displacement current?

Answer: Yes, conduction current is equal to displacement current.

(c) Determine the amplitude of B at a point $3.0\,\text{cm}$ from the axis between the plates.

Answer: Magnetic field is given as:

$$= \frac{\mu_0 r}{2\pi R^2} I_0$$

Where,

$\mu_0 =$ Free space permeability $= 4\pi \times 10^{-1}\,\mathrm{N\,A^{-2}}$

$\mathrm{I_0} =$ Maximum value of current $= \sqrt{2} I$

$\mathrm{r} =$ From the axis, the distance between the plates is $= 3.0\,\mathrm{cm} = 0.03\,\mathrm{m}$

$$B = \frac{4\pi \times 10^{-7} \times 0.03 \times \sqrt{2} \times 6.9 \times 10^{-6}}{2\pi \times (0.06)^2}$$

$$= 1.63 \times 10^{-11}\,\mathrm{T}$$

As a result, the magnetic field at that location is $1.63 \times 10^{-11}\,\mathrm{T}$.

8.3: What physical quantity is the same for X-rays of wavelength $10^{-10}\,\mathrm{m}$, red light of wavelength $6800\,\mathring{A}$ and radio waves of wavelength $500\,\mathrm{m}$?

Answer: The speed of light $\left(3 \times 10^8\,\mathrm{m/s}\right)$ in a vacuum is the same for all wavelengths. In the vacuum, it is unaffected by the wavelength.

8.4: A plane electromagnetic wave of its electric and magnetic field vectors? If the frequency of the wave is $30\,\mathrm{MHz}$, what is its wavelength?

Answer: In a vacuum, the electromagnetic wave travels in the $z-$ direction. The electric field (E) and the magnetic field (H) are in the $\mathrm{x-y}$ plane. They are perpendicular to one other. Frequency of the wave, $v = 30\,\mathrm{MHz} = 30 \times 10^6\,\mathrm{s^{-1}}$

Speed of light in a vacuum, $\mathrm{c} = 3 \times 10^8\,\mathrm{m/s}$

Wavelength of a wave is given as:

$$\lambda = \frac{c}{v}$$

$$= \frac{3 \times 10^8}{30 \times 10^6}$$

$$= 10\,\mathrm{m}$$

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

Answer: A radio may be tuned to the lowest frequency possible, $\text{v}_1 = 7.5\text{MHz} = 7.5\times10^6\ \text{Hz}$

Maximum frequency, $\text{v}_2 = 12\text{MHz} = 12\times10^6\ \text{Hz}$

Speed of light, $c = 3\times10^8\ \text{m/s}$

Corresponding wavelength for v_1 can be calculated as:

$$\lambda_1 = \frac{c}{v_1} = \frac{3\times10^8}{7.5\times10^6} = 40\,\text{m}$$

Corresponding wavelength for v_2 can be calculated as:

$$\lambda_2 = \frac{c}{v_2} = \frac{3\times10^8}{12\times10^6} = 25\,\text{m}$$

Thus, the wavelength band of the radio is $40\,\text{m}$ to $25\,\text{m}$.

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

Answer: The electromagnetic wave of the oscillator has the same frequency as a charged particle oscillating about its mean location, i.e. $10^9\ \text{Hz}$.

8.7: The amplitude of the magnetic field part of a harmonic electromagnetic wave in vacuum is $B_0 = 510\text{nT}$. What is the amplitude of the electric field part of the wave?

Answer: Magnetic field amplitude of an electromagnetic wave in a vacuum,
$B_0 = 510\text{nT} = 510\times10^{-9}\ \text{T}$

Speed of light in a vacuum, $c = 3\times10^8\ \text{m/s}$

The relationship, gives the amplitude of the electromagnetic wave's electric field.
$E = cB_0 = 3\times10^8 \times 510\times10^{-9} = 153\,\text{N/C}$

As a result, the wave's electric field component is $153\,\text{N/C}$.

8.8: Suppose that the electric field amplitude of an electromagnetic wave is $E_0 = 120\,\mathrm{N/C}$ and that its frequency is $v = 50.0\mathrm{MHz}$.

(a) Determine, B_0, ω, k and λ.

Answer: Electric field amplitude, $E_0 = 120\,\mathrm{N/C}$

Frequency of source, $\mathrm{v} = 50.0\mathrm{MHz} = 50\times10^6\,\mathrm{Hz}$

Speed of light, $\mathrm{c} = 3\times10^8\,\mathrm{m/s}$

The strength of a magnetic field is measured in magnitude as follows:

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

Angular frequency of source is given as:

$$\omega = 2\pi v$$
$$= 2\pi\times50\times10^6$$
$$= 3.14\times10^8\,\mathrm{rad/s}$$

Propagation constant is given as:

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

Wavelength of wave is given as:

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

(b) Find expressions for E and B.

Answer: 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.

Because all three vectors are perpendicular to one another, this is the case.

The electric field vector's equation is:

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

Also, the magnetic field vector is as follows:

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

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:

$$E = hv = \frac{hc}{\lambda}$$

Where,

$\text{h} =$ Planck's Constant $= 6.6\times10^{-34}\,\text{Js}$

$\text{c} =$ Speed of light $= 3\times10^8\ \text{m/s}$

$\lambda =$ 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 photon energies for various sections of the electromagnetic spectrum are listed in the table below.

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

The photon energies for distinct regions of a source's spectrum reflect the spacing of the source's relev ant energy levels.

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

(a) What is the wavelength of the wave?

Answer: Frequency of the electromagnetic wave, $v = 2.0 \times 10^{10}$ Hz

Electric field amplitude, $E_0 = 48\,\mathrm{V\,m^{-1}}$

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

Wavelength of a wave is given as:

$$\lambda = \frac{c}{v}$$
$$= \frac{3 \times 10^8}{2 \times 10^{10}}$$
$$= 0.015\,\mathrm{m}$$

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

Answer: Magnetic field strength is given as:

$$B_0 = \frac{E_0}{c} = \frac{48}{3 \times 10^8} = 1.6 \times 10^{-7}\,\mathrm{T}$$

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

Answer: The electric field's energy density is expressed as:

$$U_K = \frac{1}{2} \in_0 E^2$$

The magnetic field's energy density is given as:

$$U_B = \frac{1}{2\mu_0} B^2$$

Where,

$\epsilon_0 =$ Permittivity of free space

$\mu_0 =$ Permeability of free space

We have the relation connecting E and B as:

$$E = cB \ldots (1)$$

Where, $c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} \ldots$ (2)

When equations $(2)\&(1)$ are combined, the result is

$$E=\frac{1}{\sqrt{\epsilon_0\mu_0}}B$$

Squaring both sides, we get

$$E^2=\frac{1}{\epsilon_0\mu_0}B^2\epsilon_0E^2$$
$$=\frac{B^2}{\mu_0}\frac{1}{2}\epsilon_0E^2$$
$$=\frac{1}{2}\frac{B^2}{\mu_0}$$
$$\Rightarrow U_K=U_n$$

Additional Exercises

8.11: Suppose that the electric field part of an electromagnetic wave in vacuum is
$E=\{(3.1\mathrm{N/C})\cos\left[(1.8\mathrm{rad/m})\mathrm{y}+\left(5.4\times10^6\mathrm{rad/s}\right)\mathrm{t}\right]\}\hat{i}$ **.**

(a) What is the direction of propagation?

Answer: It may be deduced from the supplied electric field vector that the electric field is

directed in the negative x direction. As a result, the motion is in the negative y direction, i.e., $-\hat{j}$.

(b) What is the wavelength λ?

Answer: It is assumed that,

$\vec{E}=3.1\mathrm{N/C}\cos\left[(1.8\mathrm{rad/m})y+\left(5.4\times10^8\mathrm{rad/s}\right)t\right]\hat{i}$ ...(1)

In the positive x direction, the general equation for the electric field vector is:

$\vec{E}=E_0\sin(kx-\omega t)\hat{i}$ ...(2)

On comparing equations (1) and (2), we get

Electric field amplitude, $E_0=3.1\mathrm{N/C}$

Angular frequency, $\omega=5.4\times10^8\mathrm{rad/s}$

Wave number, $k=1.8\mathrm{rad/m}$

Wavelength, $\lambda = \frac{2\pi}{1.8} = 3.490\,\text{m}$

(c) What is the frequency v ?

Answer: The frequency of a wave is expressed as:

$$v = \frac{\omega}{2\pi}$$
$$= \frac{5.4\times10^{8}}{2\pi}$$
$$= 8.6\times10^{7}\ \text{Hz}$$

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

Answer: The magnetic field's strength is expressed as**:**

$$B_0 = \frac{E_0}{c}$$

Where,

$\text{c} = \text{Speed of light } = 3\times10^{8}\ \text{m/s}$

Therefore $B_0 = \frac{3.1}{3\times10^{8}} = 1.03\times10^{-7}\ \text{T}$

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

Answer: The magnetic field vector can be seen to be headed in the negative z direction when looking at the supplied vector field.

As a result, the generic equation for the magnetic field vector is:

$$\vec{B} = B_0 \cos(ky + or)\hat{k}$$
$$= \left\{\left(1.03\times10^{-7}\ \text{T}\right)\cos\left[(1.8\text{rad/m})y + \left(5.4\times10^{6}\text{rad/s}\right)t\right]\right\}\hat{k}$$

8.12: About 5% of the power of a $100\ W$ light bulb is converted to visible radiation. What is the average intensity of visible radiation? Assume that the radiation is emitted isotropically and neglect reflection.

(a) at a distance of 1m from the bulb?

Answer: Power rating of bulb, $\text{P} = 100\,\text{W}$

It is assumed that around 5% of its energy is transformed into visible light.

Therefore, Power of visible radiation,

$$P' = \frac{5}{100} \times 100 = 5\,\mathrm{W}$$

As a result, visible radiation's strength is $5\,\mathrm{W}$.

Now, the distance between a point and the bulb, $\mathrm{d} = 1\mathrm{m}$

As a result, the intensity of radiation at that position is:

$$I = \frac{P'}{4\pi d^2}$$
$$= \frac{5}{4\pi(1)^2}$$
$$= 0.398\,\mathrm{W/m^2}$$

(b) at a distance of $10\,\mathrm{m}$?

Answer: Distance of a point from the bulb, $d_1 = 10\,\mathrm{m}$.

As a result, the intensity of radiation at that point is:

$$I = \frac{P'}{4\pi (d_1)^2}$$
$$= \frac{5}{4\pi(10)^2}$$
$$= 0.00398\,\mathrm{W/m^2}$$

8.13: Use the formula $\lambda \mathrm{mT} = 0.29\,\mathrm{cm\,K}$ to obtain the characteristic temperature ranges for different parts of the electromagnetic spectrum. What do the numbers that you obtain tell you?

Answer: A body at a certain temperature produces a continuous spectrum of wavelengths.
In the case of a black substance, Planck's law defines the wavelength that corresponds to the highest i ntensity of radiation.
The connection can help you figure it out:

$$\lambda_m = \frac{0.29}{\mathrm{T}}\,\mathrm{cm\,K}$$

Where,

λ_m = maximum wavelength

T = temperature

As a result, the temperature for various wavelengths may be calculated as follows:

For $\lambda_{\mathrm{m}} = 10^{-4}\ \text{cm};\quad T = \dfrac{0.29}{10^{-4}} = 2900^{\circ}\ \text{K}$

For $\lambda_m = 5\times10^{-5}\ \text{cm};\quad T = \dfrac{0.29}{5\times10^{-5}} = 5800^{0}\ \text{K}$

For $\lambda_m = 10^{-6}\ \text{cm};\quad T = \dfrac{0.29}{10^{-6}} = 290000^{\circ}\ \text{K}$ and so on.

Temperature ranges are required for obtaining radiations in different regions of the electromagnetic sp ectrum, according to the results. The temperature rises as the wavelength grows shorter.

8.14: Given below are some famous numbers associated with electromagnetic radiations in different contexts in physics. State the part of the electromagnetic spectrum to which each belongs.

(a) 21cm **(wavelength emitted by atomic hydrogen in interstellar space).**

Answer: Radio waves are part of the electromagnetic spectrum's short wavelength end.

(b) 1057MHz **(frequency of radiation arising from two close energy levels in hydrogen; known as Lamb shift).**

Answer: It corresponds to the short wavelength end of the spectrum of radio waves.

(c) $2.7\,\text{K}$ **[temperature associated with the isotropic radiation filling all space-thought to be a relic of the 'big-bang' origin of the universe].**

Answer: Temperature, $\text{T} = 2.7^{\circ}\,\text{K}$ is given by Planck's law as:

$$\lambda_m = \frac{0.29}{2.7} = 0.11\text{cm}$$

This wavelength corresponds to microwaves.

(d) $5890\mathring{A} - 5896\mathring{A}$ **[double lines of sodium]**

Answer: This is the visible spectrum's yellow light.

(e) 14.4keV **[energy of a particular transition in** ^{57}Fe **nucleus associated with a famous high resolution spectroscopic method (Mõssbauer spectroscopy)].**

Answer: Transition energy is given by the relation,

$$E = \text{hv}$$

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

$v = \{\text{Frequency of radiation}\}$

Energy, $E = 14.4\,\text{KeV}$

Therefore,

$$v = \frac{E}{h}$$
$$= \frac{14.4 \times 10^{3} \times 1.6 \times 10^{-19}}{6.6 \times 10^{-3}}$$
$$= 3.4 \times 10^{11}\ \text{Hz}$$

This corresponds to X-rays.

8.15: Answer the following questions:

(a) Long distance radio broadcasts use short-wave bands. Why?

Answer: Shortwave bands are used for long-distance radio broadcasts because the ionosphere can only refract these bands.

(b) It is necessary to use satellites for long distance TV transmission. Why?

Answer: Spacecraft are required for long-distance TV transmissions due to the high frequencies and energy of television signals.
As a result, these signals are not reflected in the ionosphere. Satellites help in the reflection of televisi on signals consequently. They also help with long-distance television broadcasts.

(c) Optical and radio telescopes are built on the ground, but X-ray astronomy is possible only from satellites orbiting the earth. Why?

Answer: X-rays are absorbed by the atmosphere, according to X-ray astronomy.
On the other hand, visible and radio waves can travel through it. As a result, optical and radio telescop es are constructed on the ground, but only satellites orbiting the Earth are capable to conduct X-ray astronomy.

(d) The small ozone layer on top of the stratosphere is crucial for human survival. Why?

Answer: The ozone layer at the top of the atmosphere is essential for human survival because it absorbs damaging ultraviolet radiation from the sun and keeps it from reaching the Earth's surface.

(e) If the earth did not have an atmosphere, would its average surface temperature be higher or lower than what it is now?

Answer: There would be no greenhouse effect on the Earth's surface if there was no

Atmosphere.

As a result, the Earth's temperature would swiftly drop, making it cold and difficult for humans to sur vive.

(f) Some scientists have predicted that a global nuclear war on the earth would be followed by a severe 'nuclear winter' with a devastating effect on life on earth. What might be the basis of this prediction?

Answer: A global nuclear war would be catastrophic on Earth's surface. The Earth will experience a dreadful winter as a result of nuclear war, which produces clouds of smoke that cover much of the sky, preventing solar light from reaching the atmosphere. It will also add to the ozone layer's depletion.