Important Questions for Class 12

Physics

Chapter 8 - Electromagnetic Waves

Very Short Answer Type Questions **1 Mark**

1. The charging current for a capacitor is 0.25Ω. What is the displacement current across its plates?

Ans: Displacement current is equivalent to and is the same as charging current $025\,\mathrm{A}$.

2. Write the following radiations in a descending order of frequencies: red light, x-rays, microwaves, radio waves

Ans: Radiowave, Microwave, X-ray, red light

3. How does the frequency of a beam of ultraviolet light change, when it goes from air into glass?

Ans: We know that the frequency of UV light is unaffected by the frequency of a beam of ultraviolet light change and when it goes from air into glass.

4. What is the ratio of speed of gamma rays and radio waves in vacuum?

Ans: As we know that the ratio of speed of gamma rays and radio waves in vacuum is one .

5. It is necessary to use satellites for long distance TV transmission. Why?

Ans: Because television signals are not reflected by the ionosphere layer of the atmosphere, TV broadcasts from air earth stations must be reflected back to the ground via an artificial satellite.

6. What is the role of ozone layer in the atmosphere?

Ans: The main role of ozone layer in the atmosphere is that it absorbs all harmful UV rays and shield us from their detrimental effects.

7. What is the nature of waves used in radar?

Ans: The characteristics of the waves utilized in radar employs microwaves.

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

Ans: As we know that the speed of light $\left(3\times10^{8}\ \mathrm{m/s}\right)$ all wavelengths are the same in a vacuum. In the vacuum and they are unaffected by the wavelength.

Very Short Answer Type Questions **2 Marks**

1. Write the application of Infra-red radiations?

Ans: Following are the application of infra-red radiations:

(1) Photographs taken in hazy situations are taken with infrared radiation.

(2) Infrared radiations are employed to uncover the old walls' secret writings.

2. Which constituent radiation of the electromagnetic spectrum is used?

(1) To photograph internal parts of Human body-

(2) For air aircraft navigation

Ans: As the constituent radiation of the electromagnetic spectrum is -

(1) X – Rays are usually used photograph internal parts of Human body

(2) Microwaves are used for air aircraft navigation

3. Electric field in a plane electromagnetic wave is given by

$$E_z = 60\sin\left(\frac{10^3 x}{2} + \left(10^{11}\right)\frac{3t}{2}\right) V/m$$

(a). Write an expression for the magnetic field

Ans: We know that,

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

$$B_O = \frac{E_Q}{C} = \frac{60}{3\times10^6}$$

$$B_0 = 2\times10^{-7}T$$

Since magnetic field and electric field are $\perp$ to each after

$$By = 2\times10^{-7}T\sin\left(\frac{10^3}{2}x + \left(10^{11}\right)\frac{3t}{2}\right) - \cdots$$

(b) The magnitude of wavelength and frequency of the wave

Ans: Compare e.g. (1) with standard equation

$$\text{By} = \text{B}_0 \sin 2\pi\left(\frac{x}{\lambda} + \frac{t}{T}\right)$$

$$\lambda = 4\pi \times 10^{-1}\ \text{m}$$

Also $2\pi\frac{1}{T} = (10)^{11}\frac{3}{2}$

$$\frac{1}{T} = v = \frac{3\times10^{11}}{2\times2\pi}$$

$$v = \frac{3}{4\pi}\times10^{11} Hz$$

4. If the earth did not have atmosphere would its average surface temperature be higher or lower than what it is now?

Ans: The greenhouse effect traps infrared radiation inside the earth's atmosphere, causing the planet to warm. As a result, the earth's average temperature would have been law.

5. Sky waves are not used in transmitting TV signals, why? Suggest two methods by which range of TV transmission can he increased?

Ans: Sky waves are not transmitting TV signal, because the ionosphere does not reflect sky waves, they are not used to broadcast television signals.

Methods of increasing range of TV transmission

(1) Tall antenna

(2) Geostationary satellites

6. "Greater the height of a TV transmitting antenna, greater is its coverage." Explain.

Ans: As we know that ,

$$\mathrm{d} = \sqrt{2hR}$$

The distance to which TV coverage can be done will rise as height is raised.

7. A plane electromagnetic wave travels in vacuum along Z-direction. What can you say about the directions of its electric and magnetic field vectors? If the frequency of the wave is 30MHz, what is its wavelength?

Ans: In a vacuum, the electromagnetic wave travels in the -direction. In the x y plane, there is an electric field (E) and a magnetic field (M). They are perpendicular to one other.

Frequency of the wave, $v = 30\text{MHz} = 30\times10^{6}\ \text{s}^{-1}$

Speed of light in a vacuum, $c = 3\times10^{1}\ \text{m/s}$

Wavelength of a wave is given as:

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

$$= \frac{3\times10^{8}}{30\times10^{8}} = 10\ \text{m}$$

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

Ans: As we have given that**,**

A radio can tune to minimum frequency, $v_1 = 7.5\text{MHz} = 7.5\times10^{6}\ \text{Hz}$

Maximum frequency, $v_2 = 12\text{MHz} = 12\times10^{4}\ \text{Hz}$

Speed of light, $c = 3\times10^{4}\ \text{m/s}$

Then,

Corresponding wavelength far v can be calculated as:

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

$$= \frac{3\times10^{1}}{7.5\times10^{2}} = 40m$$

We get,

Corresponding wavelength far v_2 can be calculated as:

$$\lambda_2 = \frac{c}{v_2^n}$$

$$= \frac{3\times10^2}{12\times10^5} = 25\text{ m}$$

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

9. 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?

Ans: The frequency of an electromagnetic wave generated by the oscillator is the same as that of a charged particle osculating about its mean position, i.e. 10^2 Hz.

The magnetic field portion of a harmonic electromagnetic wave in vacuum has an amplitude of $B_0 = 510\text{nT}$.

10. What is the amplitude of the electric field part of the wave?

Ans: Magnetic field amplitude of an electromagnetic wave in a vacuum,

$$B0 = 510\text{nT} = 510\times10^{-7}\text{ T}$$

Speed of light in a vacuum, $c = 3\times10^2 m/s$

The relationship, gives the amplitude of the electromagnetic wave's electric field.

$$E = B_0$$

$$= 3\times108\times510\times10^{-7} = 153\text{ N/C}$$

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

Short Answer Type Questions **3 Mark**

1. In a plane electromagnetic wave, the electric field oscillates sinusoid ally with a frequency of 2×10^{16} Hz and amplitude $48\,V/m$.

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

Ans. We have given that ,

$$V = 2\times10^{Ls}\,\text{Hz}$$

$$E_0 = 48\,V/m$$

$$\lambda = \frac{C}{V} = \frac{3\times10^{2}}{2\times10^{\circ}}$$

$$\vec{A} = 1.5\times10^{-2}\,m$$

(b) Calculate the amplitude of the oscillating magnetic field.

Ans: For calculating the amplitude of the oscillating magnetic field,

We have ,

$$E_0 = cB_0$$

$$B_0 = \frac{E_Q}{C} = \frac{48}{3\times10^{2}}$$

$$B_0 = 16\times10^{-1}\ \text{Tesla}$$

(c) Calculate average energy density of the electromagnetic field at the wave

Ans: Now,

For Energy density

$$U = \frac{1}{2}8.85\times10^{-12}\times48\times48$$

$$U = 1\times10^{-2}\,J/w^{3}$$

2. Find the wavelength of electromagnetic waves of frequency 6×10^{2} Hz in free space. Give two applications of the type of wave.

Ans: We have given that ,

$V = 6\times10^{12}$ Hz

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

$\lambda = \frac{3\times10^{2}}{6\times10^{-2}}$

$\lambda = 5\times10^{-1}$ m

Following are the applications for infra-red radiations

(1) It keeps the earth warm.

(2) Infra-red lamps are used to treat muscular strains.

3. A plane monochromatic wave lies in the visible region. It is represented by the sinusoidal variation with time by the following components of electric field

$$Ex = 0, Ey = 4\sin\left[\frac{2\pi}{\lambda}(x-1t)Fz\right] = 0$$

Where $v = 5\times10^{14}$Hg And λ is the wavelength of light.

(a) What is the direction of propagation of the wave?

Ans: We know that,

(a) The direction of propagation of the wave is along the $+x =$ axis.

(b) What is its amplitude?

Ans: Amplitude= 4 units

(c) Compute the component of magnetic field?

Ans: Component of magnetic of field

$$Bz = \frac{Eo}{C} = \frac{4}{3\times10^{2}}$$

$$Bz = 1.33\times10^{-6} \text{ Tesla}$$

4. Write the characteristics of emf waves? Write the expression for velocity of electromagnetic waves in terms of permittivity and permeability of the medium?

Ans: The Characteristics of emf waves are as follows:

(1) It travels in free space with speed of light $c = 3\times10^{6}$ m / s,

(2) Electromagnetic waves are transverse in nature.

Velocity of emf waves in vacuum C $= \frac{1}{\sqrt{\mu_0 \in_6}}$

5. The electric field of a plane electromagnetic wave in vacuum is represented by -

$\mathbf{Ex = 0, Ey = 0.5\cos\left(2\pi \times 10^{8}(t - x / c)\right)}$ **and** $\mathbf{E_z = 0}$

(a) What is the direction of propagation of electromagnetic wave?

Ans: For the given equation

It represents the wave is propagating along $+\bar{x}$ - axis

(b) Determine the wavelength of the wave?

Ans: Now, by Comparing equation with the standard one

$$\text{Ey} = \text{E}_0 \cos w(t - x / c)$$

$$w = 2\pi \times 10^{2}$$

$$z'\vec{t}\text{t} = 2' z \times 10^{8}$$

$v = 10^8$

$$\Rightarrow \lambda = \frac{c}{v} = \frac{3\times10^8}{10^8}$$

$\lambda = 3m$

(c) Compute the component of associated magnetic field

Ans: As it is associated magnetic field to electric field and the direction of propagation. Since wave is propagating along $\mathrm{x} =$ axis, electric field is along, $\mathrm{y} =$ axis

Thus, magnetic field is along $z =$ axis

$\Rightarrow B_x = 0, B_y = 0$

$B_z = B_0 \cos\left(2\pi \times 10^1 (t - x/x)\right)$

$B_z = E_\ell c \cos\ (2\pi \times 10^1 (t - x/x)$

6. Find the wavelength of electromagnetic waves of frequency 5×10^{18} Hz in free space Give its two applications.

Ans: By Using $\mathrm{C} = \lambda v$

$v = 5\times10^{15}$ Hz

$\lambda = 0.6\times10^{-11} = 6\times10^{-12}$ m

These are Gamma Rays.

Applications for gamma rays :

(1) These rays are used to get information regarding atomic structure.

(2) They have very high penetrating power so they are used for detection purpose

7. (1) State the condition under which a microwave oven heats up food items containing water molecules most efficiently?

Ans: (1) Microwaves must have a frequency that is equal to the resonant frequency of the water molecules in the food item.

(2) Name the radiations which are next to these radiations in emf. Spectrum having

(a) Shorter wavelength

Ans: Visible light is the radiation are the radiation next to shorter wavelength.

(b) Longer wavelength

Ans: Microwaves light is the radiation are the radiation next to longer wavelength.

8. The terminology of different parts of the electromagnetic spectrum is given in the text. Use the formula $E = h_v$ (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?

Ans: It is given that ,

Energy of a photon is given as:

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

Where,

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

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

λ = Wavelength of radiation

$$\therefore E = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{\lambda} = \frac{19.8 \times 10^{-26}}{\lambda}$$

$$= \frac{19.8 \times 10^{-26}}{\lambda \times 1.6 \times 10^{-19}} = \frac{12.375t10^{-7}}{\lambda}\mathbf{eV}$$

The given table lists show the photon energies for different parts of an electromagnetic spectrum far different λ.

λ(m)	E(eV)
103	12.375×10^{-10}
1	12.375×10^{-1}
10^{-2}	12.375×10^{-4}
10^{-6}	12.375×10^{-1}.
10^{-1}	12.375×10^{2}
10^{-10}	12.375×10^{3}
10^{-12}	12.375×10^{2}.

The spacing of the relevant energy levels of a source is determined by the photon energies for different portions of its spectrum.

9. About 5% of the power of a $100\,\mathrm{W}$ light bulb is converted to visible radiation. What is the average intensity of visible radiation?

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

(b) at a distance of 10m ?

Assume that the radiation is emitted isotropic ally and neglect reflection.

Ans: The power rating of bulb, $P = 100\ \mathrm{W}$

It is given that about $S\%$ of its power is converted into visible radiation.

$\therefore$ Power of visible radiation,

$$P' = \frac{5}{100} \times 100 = 5\pi'$$

Hence, the power of visible radiation is $5\,\mathrm{W}$.

(a) Now, the Distance of a point from the bulb, $d = 1\,\mathrm{m}$ Hence, intensity of radiation at that point is

given as

$$1 = \frac{P'}{4\pi d^2}$$

$$= \frac{5}{4\pi(1)^2} = 0.398\mathrm{BF/m^2}$$

(b) Distance of a point from the bulb, $d_1 = 10\,\mathrm{m}$ Hence, intensity of radiation at that point is given as,

$$1 = \frac{P'}{4\pi\left(d_1\right)^2}$$

$$= \frac{5}{4\pi(10)^2} = 0.00398\ \mathrm{W/m^2}$$

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

Ans: A continuous spectrum of wavelengths is produced by a body at a specific temperature. Planck's law determines the wavelength corresponding to the greatest intensity of radiation in the case of a black substance. It can be determined by the relationship.

We know that,

$$\lambda_{\gamma} = \frac{0.29}{T} cmK$$

Where,

$\lambda_{k} =$ maximum wavelength

$T =$ temperature

Thus, the temperature for different wavelengths can be obtained as

For $\lambda_{s} = 10^{-4}$ cm ;

$$T = \frac{0.2910^{-4}}{} 2900°K$$

For $\lambda_{n} = 5 \times 10^{-5}$ cm$'$

$$T = \frac{0.29}{5 \times 10^{-5}} = 5800^{\circ} \text{K}$$

For $\lambda_{m} = 10^{-6}$ cm ;

$$T = \frac{0.29}{10^{-5}} = 290000^{\circ} \text{K}$$ and so on.

Temperature ranges are required for avoiding radiations in different sections of the electromagnetic spectrum, according to the results. As the wavelength gets shorter, the temperature gets hotter.

Long Answer Type Questions **5 Marks**

1. 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).

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

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

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

(e) 14.4 keV [energy of a particular transition in 57 Fe nucleus associated with a famous high resolution spectroscopic method

(Mossbauer spectroscopy)

Ans: By using the question we know that ,

(a) Radio waves; they belong to the electromagnetic spectrum's short wavelength end.

(b) Radio waves; they belong to the short wavelength end of the spectrum.

(c) Now, Temperature, $T = 2.7^{\circ} K$

By λ_m is given by Planck's law as:

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

Microwaves relate to this wavelength.

(d) This is the visible spectrum's yellow light.

(e) The relation gives the transition energy:

$E = h\text{v}$

Where,

$h =$ Planck's constant $= 6.6 \times 10^{-14}\, J_5$

$v =$ Frequency of radiation

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

$$\therefore v = \frac{E}{h}$$

$$= \frac{14.4\times10^{3}\times1.6\times10^{-18}}{6.6\times10^{-34}}$$

$$= 3.4\times10^{18}\ \text{Hz}$$

This corresponds to X -rays.

2. Answer the following questions:

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

Ans: Shortwave bands are used for long-distance radio broadcasts because only these bands can be refracted by the ionosphere.

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

Ans: Because television signals have high frequencies and energy, satellites are required for long-distance TV transmissions. As a result, the ionosphere does not reflect these signals. As a result, satellites aid in the reflection of television transmissions.

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

Ans: As far as -ray astronomy is concerned, -rays are absorbed by the atmosphere. Visible and radio waves, on the other hand, can pass through it. As a result, optical and radio telescopes are constructed on the ground, but X-ray astronomy is only conceivable thanks to satellites orbiting the Earth.

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

Ans: The ozone layer at the top of the atmosphere is critical 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?

Ans: There would be no greenhouse effect on the Earth's surface if it did not have an atmosphere. As a result, the Earth's temperature would swiftly drop, making it cold and uncomfortable to live on and difficult for human survival.

(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?

Ans: On the surface of the Earth, a global nuclear war would be catastrophic. The Earth will experience a harsh winter following a nuclear war because the war will produce clouds of smoke that will cover the majority of the sky, preventing solar light from reaching the atmosphere. It will also contribute to the ozone layer's depletion.

3. Suppose that the electric field part of an electromagnetic wave in vacuum is

$$E = \left\{(3.1\,\mathrm{N/C})\cos\left[(1.8\,\mathrm{rad/m})y + \left(5.4\times10^{6}\,\mathrm{rad/s}\right)t\right]\right\}^{*}_{i}$$

(a) What is the direction of propagation?

Ans: It may be deduced from the supplied electric field vector that the electric field is directed in a negative direction. As a result, the movement is in the negative direction .i.e., $-j$.

(b) What is the wavelength λ ?

Ans: It is given that,

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

The general equation for the electric field vector in the positive x direction can be written as:

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

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, $k = 1.8\text{rad}/\text{m}$

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

(c) What is the frequency v ?

Ans: Now, Frequency of wave is given as:

$$\lambda = \frac{2\pi}{1.8}$$

$$= \frac{5.4\times10^{3}}{2\pi} = 8.6\times10^{7}\text{ Hz}$$

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

Ans: We know that ,

Magnetic field strength is given as:

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

Where,

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

$$\therefore B_0 = \frac{3.1}{3\times10^{8}} = 1.03\times10^{-1}T$$

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

Ans: When looking at the given vector field, it's clear that the magnetic field vector is pointing in the wrong direction. As a result, the magnetic field vector's general equation is expressed as:

$$\vec{B} = B_0\cos(ky + (i)t)\hat{k}$$

$$= \left\{\left(1.03\times10^{-7}T\right)\cos\left[(1.8\text{rad}/\text{m})y + \left(5.4\text{ K}t10^{6}\text{rad}/\text{s}\right)t\right]\right\}\hat{k}$$

4. In a plane electromagnetic wave, the electric field oscillates sinusoid ally at a frequency of 2.0×10^{10}Hz and amplitude $48\text{v}^{-1}\text{m}$.

(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 $=3\times10^{8}\ \text{m s}^{-1}$]

Ans: As it is given that,

Frequency of the electromagnetic wave, $v=2.0\times10^{10}\ \text{Hz}$

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

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

(a) Now,

Wavelength of a wave is given as:

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

$$=\frac{3\times10^{8}}{2\times10^{12}}=0.015m$$

(b) Where,

Magnetic field strength is given as:

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

$$=\frac{48}{3\times10^{2}}=1.6\times10^{-7}T$$

(c) Then,

Energy density of the electric field is given as:

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

And, energy density of the magnetic field is given as:

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

Where,

E0 - Permittivity of free space

$\mu_0 =$ Permeability of free space

We have the relation connecting E and B as:

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

Where,

Putting equation (2) in equation (1), we get

Squaring both sides, we get

$$\Rightarrow U_E = U_B$$

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

Ans: Given that,

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

Frequency of source, $v = 50.0\mathrm{MHz} = 50 \times 10^5\ \mathrm{Hz}$

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

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

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

$$= \frac{120}{3 \times 10^2}$$

$= 4\times10^{-7}T = 400nT$

Angular frequency of source is given as:

$$\omega = 2m = 2\pi \times 50\times10^{6}$$

$$= 3.14\times108 \text{rad}/\text{s}$$

Propagation constant is given as:

$$k = \frac{(i)}{c}$$

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

Now,

Wavelength of wave is given as:

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

$$= \frac{3\times10^{8}}{50\times10^{2}} = 6.0 \text{ m}$$

(b) Assume the wave is travelling in a positive direction. The electric field vector will then point in the positive direction, and the magnetic field vector will also point in the positive direction. This is due to the fact that all three vectors are perpendicular to one another.

Equation of electric field vector is given as:

$$\bar{E} = E_0 \sin(kc - (i)t)\, j$$

$$= 120 \sin\left[1.05x - 3.14\times10^{1}t\right] j$$

And, magnetic field vector is given as:

$$\bar{B} = B_0 \sin(kx - (t)t)\hat{k}$$

$$\vec{B} = \left(4\times10^{-1}\right)\sin\left[1.05x - 3.14\times10^{9}t\right]\hat{k}$$

6. A parallel plate capacitor (Fig. 8.7) made of circular plates each of radius $R = 6.0\text{ cm}$ **has a capacitance** $C = 100\text{pF}$**. The capacitor is connected to a** 230 V **ac supply with a (angular) frequency of** 300rads^{-1}

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

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

(c) Determine the amplitude of B **at a point** 3.0 cm **from the axis between the plates**.

Ans: Given that,

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

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

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

Angular frequency, $\omega = 300\text{rads}^{-1}$

(a) Rms value of conduction current, $I = \dfrac{V}{X_\ell}$

Where,

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

$$\therefore I = V \times \omega C$$

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

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

$= 6.9 \text{HA}$

Hence, the rms value of conduction current is 6.9 μA

(b) Yes, the displacement current equal to conduction current is

(c) Where Magnetic field is given as:

$$B = \frac{\mu_e r^r}{2\pi R^2} I_e$$

Where,

$\mu_0 =$ Free space permeability $= 4\pi \times 10^{-7}\ \text{N}A^{-1}$

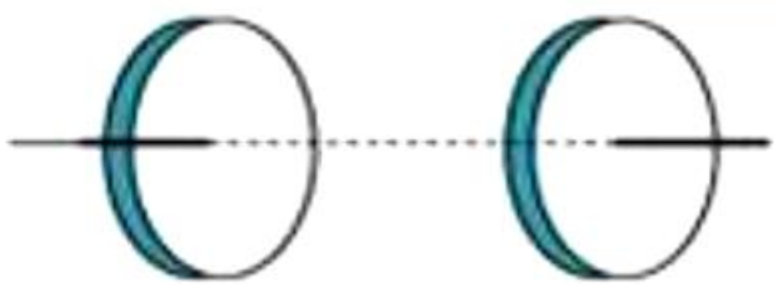
$10 =$ Maximum value of current $= \sqrt{2} l$

$r =$ Distance between the plates from the axis $= 3.0\ \text{cm} = 0.03\ \text{m}$

$$\therefore B = \frac{4\pi \times 10^{-7} \times 0.03 \times \sqrt{2} \times 6.9 \times 10^{-5}}{2\pi > 0(06)^2}$$

$= 1.63 \times 10^{-11} T$ Hence, the magnetic field at that point is $1.63 \times 10^{-11} T$.

7: Figure 8.6 shows a capacitor made of two circular plates each of radius 12 cm, and separated by 5.0 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 A



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

(b) Obtain the displacement current across the plates.

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

Ans: Given data,

Radius of each circular plate, $r = 12\text{ cm} = 0.12\text{ m}$

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

Charging current, $I = 0.15\text{ A}$

Permittivity of free space, $\varepsilon_0 = 8.85\times10^{-12}\text{C2 N}^{-1}\text{ m}^{-2}$

(a) Capacitance between the two plates is given by the relation,

$$C = \frac{\varepsilon_0 A}{d'}\lambda = \frac{c}{v} = \frac{3\times10^8}{30\times10^6} = 10m$$

Where,

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

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

$$= \frac{8.85\times10\pi^{12}\times0k2()^2}{0.05}$$

$$-8.0032\times10^{-12}F = 80.032\,pF$$

Charge on each plate, $q = CV$

Where,

V = Potential difference across the plates

Differentiation on both sides with respect to time (t) gives:

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

But $\frac{dq}{at}$ = current (I)

$$\therefore \frac{dV}{dt} = \frac{1}{C}$$

$$\Rightarrow \frac{0.15}{80.032 \times 10^{-1.2}} = 1.87 \times 10^{9}\ \text{V/s}$$

Therefore, the change in potential difference between the plates is $1.87 \times 10^{9}\ \text{V/s}$.