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PHYSICS

BOOKS - CHHAYA PHYSICS (BENGALI ENGLISH)

ELECTROMAGNETIC WAVES

Numerical Examples

1. In the velocity of em wave in vacuum is $3 \times 10^8 m.\, s^{-1}$ and the magnetic permeability of vacuum is $4\pi \times 10^{-7} N.\, C^{-2}.\, s^2$, find the electric permittivity of vacuum.

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2. Amplitude of electric field of a plane electromagnetic wave is $48V.m^{-1}$. What is the amplitude of the magnetic field of the wave ?

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3. Electric field of an electromagnetic wave is , $E = 10^{-5}$ sin $\left(12 \times 10^{15}t - 4 \times 10^{7}x\right)$.Find the frequency , velocity , wavelength of the wave . Write the equation of the magnetic field corresponding to this wave. Assume all quantities in SI unit.

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4. In an electromagnetic field , the amplitude of electric field at a point is 3 V. m^{-1} . Calculate energy density and intensity of the wave at that point. Given $\mu_0 = 4\pi \times 10^{-7}H.m^{-1}$

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5. A rectangular parallel plate capacitor of dimension 5 cm x 4 cm is charging in such a way that the rate of change of electric field between the two plates is $5.65 \times 10^{11} V.m^{-1}.s^{-1}$. Calculate the displacement current for this capacitor .

Given $\in_0 = 8.85 \times 10^{-12} F.m^{-1}$

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6. Calculate the intensity and the rms value of electric field of electromagnetic waves at a distance 10 m from a 100 W electric bulb . Given $\in_0 = 8.85 \times 10^{-12} F.m^{-1}$

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Section Related Questions

1. Write down the expression of displacement current .

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2. Define electromagnetic wave.

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3. In vibrational spectroscopy , which type of waves is used ? What is the source of this type of waves ?

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4. Write down the range of wavelength of X-rays.

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5. Write down the uses of radio waves.

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6. Arrange the following waves according to the wavelength in ascending order of their magnitudes:

Visible light, Ultraviolet waves, Microwaves, Radio waves, X-rays, Infrared waves, Gamma rays.

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7. Write down two properties of electromagnetic waves.

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8. Write down the two expressions by which electric and magnetic fields of an electromagnetic wave can be represented.

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9. Write down an expression for speed of electromagnetic wave in free space in terms of μ_0 and $\in_0$.

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10. Write different kinds of EM waves.

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11. Show that , the energy density in an electromagnetic field, $u = \in_0 E_0^2 = \frac{1}{\mu_0} B_0^2$

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12. What do you mean by the intensity of electromagnetic radiation at a point ? Show that , Intensity I=cu.

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13. What is radiation pressure ? Mention its relation with density of radiated energy .

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14. Draw a neat diagram showing the direction of electric (E) and magnetic (B) field vectors in an electromagnetic wave with the direction of the velocity v of propagation of the wave.

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Hots Questions

1. Sound waves, unlike electromagnetic waves, cannot travel through vacuum. Why?

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2. Electric field or magnetic field can independently exist In nature, but in electromagnetic waves, neither electric field or magnetic field can exist independently. Why?

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3. Electric field and magnetic field of an electromagnetic wave advance as sinusoidal waves. Instead of being sinusoidal, if these fields had been different periodical waves, state whether any electromagnetic wave would have been formed or not.

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4. Name any two electromagnetic waves. State any one similarity and one dissimilarity between them.

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5. Light waves can travel in vacuum but sound waves require a material medium. Why?

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Ncert Textbook Questions

1. A capacitor is 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. The charging current is constant and equal to 0.15 A.

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

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2. A capacitor is 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. The charging current is constant and equal to 0.15 A.

Obtain the displacement current across the plates.

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3. A capacitor is 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. The charging current is constant and equal to 0.15 A.

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

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4. Which physical quantity is the same for X-rays of wavelength 10^{-10} m, red light of wavelength 6800 Å and radio waves of wavelength 500 m?

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5. 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 30 MHz, what is its wavelength?

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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?

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

What is the wavelength of the wave?

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

What is the amplitude of the oscillating magnetic field?

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

Show that the average energy density of the electric field equals the average energy density of the magnetic field. $\left[c = 3 \times 10^{8} m.\, s^{-1}\right]$

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

$$\vec{E} = \left[\left(3.1N.\, C^{-1}\right)\cos\left\{1.8\text{rad.}\, m^{-1}\right)y + \left(5.4 \times 10^{6}\text{rad.}\, s^{-1}\right)t\right\}\Big]\hat{i}$$

What is the direction of propagation?

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

$$\vec{E} = \left[\left(3.1N.C^{-1}\right)\cos\left\{1.8\text{rad}.\,m^{-1}\right)y + \left(5.4\times10^{6}\text{rad}.\,s^{-1}\right)t\right\}\Big]\hat{i}$$

What is the wavelength,λ ?

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

$$\vec{E} = \left[\left(3.1N.C^{-1}\right)\cos\left\{1.8\text{rad}.\,m^{-1}\right)y + \left(5.4\times10^{6}\text{rad}.\,s^{-1}\right)t\right\}\Big]\hat{i}$$

What is the frequency, f?

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

$\vec{E} = \left[\left(3.1N.C^{-1}\right)\cos\left\{1.8\text{rad}.m^{-1}\right)y + \left(5.4 \times 10^{6}\text{rad}.s^{-1}\right)t\right\}\hat{i}$

What is the amplitude of the magnetic field part of the wave?

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

$\vec{E} = \left[\left(3.1N.C^{-1}\right)\cos\left\{1.8\text{rad}.m^{-1}\right)y + \left(5.4 \times 10^{6}\text{rad}.s^{-1}\right)t\right\}\hat{i}$

Write an expression for the magnetic field part of the wave.

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15. 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.

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

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16. 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. 1057 MHz (frequency of radiation arising from two close energy levels in hydrogen, known as Lamb shift)

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17. 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.

5890 Å-5896 Å (double lines of sodium)

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18. 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.

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

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19. Why long distance radio broadcasts use short wave bands?

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20. Why use of satellites is necessary for long distance TV transmission?

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21. Optical and radio telescopes are built on ground but X-rays astronomy is possible only from satellites orbiting the earth. Why?

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

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

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Ncert Exemplar Questions

1. One requires 11 eV of energy to dissociate a carbon monoxide molecule into carbon and oxygen atoms. The minimum frequency of the appropriate electromagnetic radiation to achieve the dissociation lies in

A. visible region

B. infrared region

C. ultraviolet region

D. microwave region

Answer:

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2. A linearly polarized electromagnetic wave given by $\vec{E} = E_0 \hat{i} \cos(kz - \omega t)$ is incident normally on a perfectly reflecting infinite wall at z = a. Assuming that the material of the wall is optically inactive, the reflected wave will be given as

A. $\vec{E}_r = -E_0 \hat{i} \cos(kz - \omega t)$

B. $\vec{E}_r = E_0 \hat{i} \cos(kz + \omega t)$

C. $\vec{E}_r = -E_0 \hat{i} \cos(kz + \omega t)$

D. $\vec{E}_r = E_0 \hat{i} \sin(kz - \omega t)$

Answer:

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3. An EM wave radiates outward from a dipole antenna, with E_0 as the amplitude of its electric field vector. The electric field E_0 which transports significant energy from the source falls off as

A. $\frac{1}{r^3}$

B. $\frac{1}{r^2}$

C. $\frac{1}{r}$

D. remains constant

Answer: C

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4. The ratio of contributions made by the electric field and magnetic field components to the intensity of an EM wave is

A. $c:1$

B. $c^2:1$

C. $1:1$

D. $\sqrt{c}:1$

Answer: C

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5. A plane electromagnetic wave propagating along x-direction can have the following pairs of $\vec{E}$ and $\vec{B}$

A. E_x, B_y

B. E_y, B_z

C. B_x, E_y

D. E_z, B_y

Answer: B::D

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6. A charged particle oscillates about its mean equilibrium position with a frequency of 10^9 Hz. The electromagnetic wave produced -

(A) Will have frequency of 10^9 Hz.

(B) Will have frequency of 2×10^9 Hz.

(C) Will have a wavelength of 0.3 m.

(D) Fall in the region of radio waves.

A. will have frequency of 10^9 Hz

B. will have frequency of 2×10^9 Hz

C. will have a wavelength of 0.3 m

D. fall in the region of radio waves

Answer: A::C::D

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7. The source of electromagnetic waves can be a charge -

(A) Moving with a constant velocity.

(B) Moving in a circular orbit.

(C) At rest.

(D) Falling in an electric field.

A. moving with a constant velocity

B. moving in a circular orbit

C. at rest

D. falling in an electric field

Answer: B::D

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Exercise Mcq

1. μ_0 and $\in_0$ are the magnetic permeability and the electric permittivity, respectively, of free space. ϕ is the electric flux across any Gaussian surface. Then the displacement current is defined as

A. $\frac{d\phi}{dt}$

B. $\in_0 \frac{d\phi}{dt}$

C. $\mu_0 \frac{d\phi}{dt}$

D. $\mu_0 \in_0 \frac{d\phi}{dt}$

Answer: B

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2. Electric flux enclosed by a surface A is given by -

$(A)\ \in_0 \int \vec{E} . d\vec{A}$

$(B)\ \frac{1}{\in_0} \int \vec{E} . d\vec{A}$

$(C)\ \in_0 \mu_0 \int \vec{E} . d\vec{A}$

$(D)\ \int \vec{E} . d\vec{A}$

A. $\in_0 \int \vec{E} \cdot d\vec{A}$

B. $\frac{1}{\in_0} \int \vec{E} \cdot d\vec{A}$

C. $\in_0 \mu_0 \int \vec{E} \cdot d\vec{A}$

D. $\int \vec{E} \cdot d\vec{A}$

Answer: B

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3. Electromagnetic waves are produced by -

(A) A static charge.

(B) A uniformly moving charge.

(C) An accelerated charge.

(D) Neutral particles.

A. a static charge

B. a uniformly moving charge

C. An accelerated charge

D. neutral particles

Answer: C

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4. Of the following frequencies, which one may be the frequency of a radio wave?

A. 10^2 Hz

B. 10^8 Hz

C. 10^{14} Hz

D. 10^{20} Hz

Answer: B

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5. Of the following frequencies, which one may be the frequency of X-rays?

A. 10^2 Hz

B. 10^8 Hz

C. 10^{14} Hz

D. 10^{20} Hz

Answer: D

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6. Of the following frequencies, which one may be the frequency of an infrared wave?

A. 10^2 Hz

B. 10^8 Hz

C. 10^{14} Hz

D. 10^{20} Hz

Answer: C

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7. Wavelengths of microwave, ultraviolet and infrared rays are λ_m, λ_n and λ_i , respectively. Which one of the following is correct?

A. $\lambda_m > \lambda_n > \lambda_i$

B. $\lambda_i > \lambda_n > \lambda_m$

C. $\lambda_n > \lambda_i > \lambda_m$

D. $\lambda_m > \lambda_i > \lambda_n$

Answer: D

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8. Which one of the following is not an electromagnetic wave?

A. cosmic ray

B. γ -rays

C. β-rays

D. X-ray

Answer: C

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9. Which of the following has the shortest wavelength?

A. microwaves

B. ultraviolet rays

C. X-rays

D. infrared rays

Answer: C

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10. Frequency orders of γ-rays, X-rays, UV rays are a, b and c respectively. Which of the following is correct?

A. a gt b, b lt c

B. agtb , bgtc

C. altb , bgtc

D. a = b = c

Answer: B

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11. The decreasing order of wavelength of infrared, micro- wave, ultraviolet and gamma rays is

A. microwave, infrared, ultraviolet, gamma rays

B. gamma rays, ultraviolet, infrared, microwaves

C. microwaves, gamma rays, infrared, ultraviolet

D. infrared, microwave, ultraviolet, gamma rays

Answer: A

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12. Electromagnetic wave is a kind of -

(A) Matter wave

(B) Stationary wave

(C) Longitudinal wave

(D) Progressive wave

A. matter wave

B. stationary wave

C. longitudinal wave

D. progressive wave

Answer: D

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13. Which phenomenon proves that electromagnetic waves are transverse waves?

A. polarisation

B. interference

C. reflection

D. diffraction

Answer: A

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14. The ratio between the amplitudes of electric and magnetic fields at any point on a progressive electromagnetic wave in free space is equal to

A. $\frac{1}{\mu_0 \in_0}$

B. $\frac{1}{\sqrt{\mu_0 \in_0}}$

C. $\sqrt{\mu_0 \in_0}$

D. $\mu_0 \in_0$

Answer: B

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15. In a plane electromagnetic wave, the electric field (E) having amplitude of 48 . V m^{-1} oscillates at a frequency of 2.0×10^{10} Hz. The amplitude of the oscillating magnetic field (B) is

A. 3.2×10^{-8}T

B. 3×10^{7} T

C. 16×10^{-7} T

D. 1.6×10^{-7} T

Answer: D

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16. The electric and the magnetic field associated with an em wave propagating along the +z-axis can be represented by

A. $\left[\vec{E} = E_0\hat{i}, \vec{B} = B_0\hat{j}\right]$

B. $\left[\vec{E} = E_0\hat{k}, \vec{B} = B_0\hat{i}\right]$

C. $\left[\vec{E} = E_0\hat{j}, \vec{B} = B_0\hat{i}\right]$

D. $\left[\vec{E} = E_0\hat{j}, \vec{B} = B_0\hat{k}\right]$

Answer: A

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17. An electromagnetic wave in vacuum has the electric and magnetic fields $\vec{E}$ and $\vec{B}$, which are always perpendicular to each other. The direction of polarization is given by $\vec{X}$ and that of wave propagation by $\vec{k}$. Then

A. $\vec{X} \parallel \vec{E}$ and $\vec{k} \parallel \vec{E} \times \vec{B}$

B. $\vec{X} \parallel \vec{B}$ and $\vec{k} \parallel \vec{E} \times \vec{B}$

C. $\overrightarrow{X} \mid \mid \overrightarrow{E}$ and $\overrightarrow{k} \mid \mid \overrightarrow{B} \times \overrightarrow{E}$

D. $\overrightarrow{X} \mid \mid \overrightarrow{B}$ and $\overrightarrow{k} \mid \mid \overrightarrow{B} \times \overrightarrow{E}$

Answer: A

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18. The electric field associated with an em wave in vacuum is given by $\overrightarrow{E} = 40\cos\left(kz - 6 \times 10^8 t\right)\hat{i}$, where E, z and t are in V. m^{-1}. meter and seconds respectively. The value of wave vector k is

A. $2m^{-1}$

B. $0.5m^{-1}$

C. $6m^{-1}$

D. $3m^{-1}$

Answer: A

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Exercise Very Short Answer

1. The current which comes into play in a region where the electric flux is changing with time is called_____.

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2. Write down the mathematical form of Ampere-Maxwell's law.

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3. Wavelengths of visible light, X-rays and infrared rays are λ_1, λ_2 and λ_3 , respectively. Arrange them in ascending order of their magnitudes.

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4. Of X-rays, γ-rays and ultraviolet rays, which one has the maximum frequency?

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5. Which part of the electromagnetic spectrum has the largest penetrating power?

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6. Name the electromagnetic waves that have frequencies greater than those of ultraviolet light but less than those of gamma rays.

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7. Find the wavelength, in angstrom unit, of electromagnetic waves of frequency 5×10^{19} Hz in free space.

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8. An electromagnetic wave is propagating along positive z-axis. At any moment, if the direction of the magnetic field at a point be along positive x-axis, what will be the direction of the electric field at that point?

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9. What is the velocity of a radio wave in vacuum?

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10. Light is a progressive wave of_____ and _____ fields.

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11. Electromagnetic wave is a _____ progressive wave.

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12. Write down the relation among velocity of electromagnetic waves, magnetic permeability of vacuum and electric permittivity

of vacuum.

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13. Which physical quantity is expressed by the ratio of the amplitudes of electric and magnetic fields for an electro magnetic wave.

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14. What is the ratio of velocities of light rays of wavelengths 4000 Å and 8000 Å in vacuum?

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15. What is the ratio of speeds of infrared rays and ultraviolet rays in vacuum?

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16. Which physical quantity, if any, has the same value waves belonging to the different parts of the electromagnetic spectrum?

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Exercise Short Answer Type Question I

1. Why did Maxwell have to modify Ampere's circuital law?

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2. How is the velocity of an electromagnetic wave in a medium related with the electric and the magnetic properties of that medium?

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3. Write down one similarity and one dissimilarity between visible light and radio wave.

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Exercise Short Answer Type Question Ii

1. Electromagnetic waves propagate through free space or a medium as transverse waves. The electric and magnetic fields are

perpendicular to each other as well as perpendicular to the direction of propagation of waves at each point. In the direction of wave propagation, electric field $\overrightarrow{E}$ and magnetic field $\overrightarrow{B}$ form a right-handed cartesian coordinate system. During the propagation of electromagnetic wave, total energy of electromagnetic wave is distributed equally between electric and magnetic fields. Since $\in_0$ and μ_0 are permittivity and permeability of free space, the velocity of electromagnetic wave, $c = (\in_0 \mu_0)^{-1/2}$. Energy density i.e., energy in unit volume due to electric field at any point, $u_E = \frac{1}{2} \in_0 E^2$ Similarly, energy density due to magnetic field , $u_M = \frac{1}{2\mu_0} B^2$. If the electromagnetic wave propagates along x-direction, then the equations of electric and magnetic field are respectively.

$E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$

Here, the frequency and the wavelength of oscillating electric and magnetic fields are $f = \frac{\omega}{2\pi}$ and $\lambda = \frac{2\pi}{k}$ respectively. Thus $E_{\text{rms}} = \frac{E_0}{\sqrt{2}}$ and $B_{\text{rms}} = \frac{B_0}{\sqrt{2}}$, where $\frac{E_0}{B_0} = c$. Therefore,

average energy density $\bar{u}_E = \frac{1}{2} \in_0 E_{\text{rms}}^2$ and $\bar{u}_M = \frac{1}{2\mu_0} B_{\text{rms}}^2$.

The intensity of the electromagnetic wave at a point, $I = c\bar{u} = c(\bar{u}_E + \bar{u}_B)$.

To answer the following questions , we assume that in case of propagation of electromagnetic wave through free space, $c = 3 \times 10^8 m.\, s^{-1}$ and $\mu_0 = 4\pi \times 10^{-7} H.\, m^{-1}$

If the peak value of electric field at a point in electromagnetic wave is 15 V . m^{-1}, then average electrical energy density (in j . m^{-3})

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Exercise Problem Set I

1. The area of each plate of a parallel plate air capacitor is $113 cm^2$ and the separation between the plates is 4 mm. During charging of the capacitor, the electric field inside the gap

changes almost uniformly from $5mV.m^{-1}$ to 6 mV . m^{-1} in 10^{-10} second. Find out the displacement current at that instant. Given, $\in_0 = 8.854 \times 10^{-12} F.m^{-1}$

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2. The wavelength of a microwave and that of an ultrasonic wave are equal. What is the ratio of their frequencies?

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3. A radio-station broadcasts Bibidha Bharati with radio waves of wavelength 219 m. What will be its frequency in MHz?

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4. The permittivity and the permeability of vacuum area $\in_0 = 8.85 \times 10^{-12} C^2 . N^{-1} . m^{-2}$ and $\mu_0 = 4\pi \times 10^{-7} N . s^2 . C^{-2}$. What is the velocity of an electromagnetic wave?

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5. The peak value of the electric field of a plane radio wave is $10^{-4} V . m^{-1}$ .What is the peak value of the magnetic field?

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6. In an electromagnetic wave, the electric field is $E = 5 \sin\left(10^{12} t - \frac{x}{3 \times 10^3}\right) V . m^{-1}$. Calculate the intensity of that wave. Given $\mu_0 = 4\pi \times 10^{-7} H . m^{-1}$

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Exercise Problem Set Ii

1. How would you establish an instantaneous displacement current of 5.0 A in the space between the two parallel plates of 1 μF capacitor?

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2. A parallel plate capacitor of separation 2 mm is connected in an electric circuit having source voltage 400 V. If the plate area is $60cm^2$, then find out the value of displacement current for 10^{-6} s.

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3. Obtain the temperature ranges for ultraviolet part of radiation of electromagnetic waves. Use the formula,$\lambda_m T = 2.9 \times 10^{-3} m$ .K. Take frequency ranges for ultra violet part of radiation is 8×10^{14} Hz to 5×10^{17} Hz

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4. Calculate the wavelengths in vacuum for (a) blue light ($f = 6.34 \times 10^{14}$ Hz) and (b) Orange light ($f = 4.95 \times 10^{14}$ Hz).

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5. Average intensity of the solar energy incident on the earth's surface is $1300 W . m^{-2}$. Calculate the rms values of electric and magnetic fields due to this radiation near the earth's surface. (Given $\mu_0 = 4\pi \times 10^{-7} H . m^{-1}$)

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6. Average distance of the sun from the earth is 1.5×10^8 km and the average intensity of sunlight incident on the earth's surface is 1300 W . m^{-2}. Calculate the energy radiated per second from the surface of the sun.

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7. The equation of the electric field associated with an electromagnetic wave is $E = 0.001 \sin\left(10^{14}t - \frac{1}{3} \times 10^{-8}x\right) V.m^{-1}$. What is the (i) frequency, (ii) wavelength of this wave? Establish the equation of the associated magnetic field.

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8. The intensity of an electromagnetic field at a point is $0.006W.m^{-2}$. Find out the electric field amplitude and the energy density at that point. Given $\mu_0 = 4\pi \times 10^{-7} H.m^{-1}$

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Exercise Hots Numberical Problems

1. A parallel plate capacitor is made out of two rectangular metal plates of sides 30 cm x 15 cm separated by a distance of 2 mm. The capacitor is charged in such a way that the charging current has a constant value of 100 mA. What must be the rate of change of potential of the charging source and what will be the displacement current in the region between the capacitor plates?

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2. A plane electromagnetic wave propagating along the x-direction has a wavelength of 6 mm. The electric field is along the y-direction and its maximum magnitude is $33V.m^{-1}$. Write down the equations for the electric and magnetic fields as a function of x and t.

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3. In a plane electromagnetic wave, the electric field sinusoidally oscillates at a frequency 2×10^{10} Hz and amplitude 45 V $.m^{-1}$.

(i) What is the wavelength of the wave?

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

(iii) Find out the relation between average energy density of the electric field $\vec{E}(u_E)$ and the average energy density of the magnetic field $\vec{B}(u_B)$

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Entrance Corner Assertion Reason

1. Statement I: The electric field $\overrightarrow{E}$ and the magnetic field $\overrightarrow{B}$ are mutually perpendicular at a point in the electromagnetic wave.

Statement II: Electromagnetic waves are transverse waves.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: B

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2. Statement I: Electromagnetic waves are transverse waves.

Statement II: Electromagnetic waves have the property of polarization.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: A

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3. Statement I: The ratio of the amplitudes of electric and magnetic fields at a point in the electromagnetic wave is same as the velocity of wave.

Statement II: If in a medium, μ and $\in$ are the magnetic permeability and the electric permittivity respectively, then $1/\sqrt{\mu \in}$ is the velocity of electromagnetic wave in that medium.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: D

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4. Statement I: During the propagation of visible light and X-rays as electromagnetic waves, X-rays carry more energy than visible light despite both of them have same amplitudes of electric fields at a point.

Statement II: The frequency of X-rays is much higher than that of visible light.

(A) Statement I is true, statement II is true, statement II is a correct explanation for statement I.

(B) Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

(C) Statement I is true, statement II is false.

(D) Statement I is false, statement II is true.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: D

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5. Statement 1: During the propagation of electromagnetic wave along z-axis, if the electric field $\vec{E}$ at a point is along x-axis, then

the magnetic field $\overrightarrow{B}$ at that point will be along y-axis.

Statement II: In the direction of propagation of electromagnetic wave, the electric field $\overrightarrow{E}$ and the magnetic field $\overrightarrow{B}$ both form a right-handed cartesian coordinate system

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: C

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Entrance Corner Mcq

1. Electromagnetic waves -

(A) Can show interference

(B) Can be polarised

(C) Are deflected by electric field

(D) Are deflected by magnetic field

A. can show interference

B. can be polarised

C. are deflected by electric field

D. are deflected by magnetic field

Answer: A::B

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2. During the propagation of electromagnetic wave in vacuum, the electric field $\overrightarrow{E}$ and the magnetic field $\overrightarrow{B}$ at each point -

(A) Are mutually perpendicular.

(B) Are in same phase.

(C) Carry equal amount of energy by dividing average energy of the wave between them.

(D) The ratio of amplitude of these fields is equal to the speed of light.

A. are mutually perpendicular

B. are in same phase

C. carry equal amount of energy by dividing average energy of the wave between them

D. the ratio of amplitude of these fields is equal to the speed of light

Answer: A::C

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3. When the electromagnetic wave enters into a medium from free space,

(A) Velocity of the wave decreases

(B) Frequency of the wave decreases

(C) Wavelength of the wave decreases

(D) Frequency increase and wavelength decreases

A. velocity of the wave decreases

B. frequency of the wave decreases

C. Wavelength of the wave decreases

D. frequency increase and wavelength decreases

Answer: A, C

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4. c and v are the velocities of an electromagnetic wave in free space of permittivity $\in_0$ and permeability μ_0 and in a medium of permittivity $\in$ and μ permeability respectively. If the refractive index of the medium is n, then which of the following relations are correct?

A. $c = \frac{1}{\sqrt{\mu_0 \in_0}}$

B. $v = \frac{1}{\sqrt{\mu \in}}$

C. $n = \frac{v}{c}$

D. $n = \sqrt{\frac{\mu \in}{\mu_0 \in_0}}$

Answer: A::B::D

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5. On the surface of earth, average intensity of sunlight 1300 W . m^{-2}. If electric permittivity of free space or air is $8.845 \times 10^{-12} F.\, m^{-1}$,Find the amplitude of magnetic field.

A. average amplitude of the electric field in the earth surface is almost 990 V . m^{-1}

B. average amplitude of the magnetic field in the earth surface is almost $3.3 \times 10^{-8} Wb.\, m^{-2}$

C. average energy density of sunlight in the earth surface is almost $4.33 \times 10^{-6} J.\, m^{-3}$

D. in case of normal incidence, the polarisation surface is parallel to the earth surface

Answer: A::B::D

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Entrance Corner Comprehension

1. Electromagnetic waves propagate through free space or a medium as transverse waves. The electric and magnetic fields are perpendicular to each other as well as perpendicular to the direction of propagation of waves at each point. In the direction of wave propagation, electric field $\overrightarrow{E}$ and magnetic field $\overrightarrow{B}$ form a right-handed cartesian coordinate system. During the propagation of electromagnetic wave, total energy of electromagnetic wave is distributed equally between electric and magnetic fields. Since $\in_0$ and μ_0 are permittivity and permeability of free space, the velocity of electromagnetic wave,

$c = (\in_0 \mu_0)^{-1/2}$. Energy density i.e., energy in unit volume due to electric field at any point, $u_E = \frac{1}{2} \in_0 E^2$ Similarly, energy density due to magnetic field , $u_M = \frac{1}{2\mu_0} B^2$. If the electromagnetic wave propagates along x-direction, then the equations of electric and magnetic field are respectively.

$E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$

Here, the frequency and the wavelength of oscillating electric and magnetic fields are $f = \frac{\omega}{2\pi}$ and $\lambda = \frac{2\pi}{k}$ respectively. Thus $E_{\text{rms}} = \frac{E_0}{\sqrt{2}}$ and $B_{\text{rms}} = \frac{B_0}{\sqrt{2}}$, where $\frac{E_0}{B_0} = c$. Therefore, average energy density $\bar{u}_E = \frac{1}{2} \in_0 E_{\text{rms}}^2$ and $\bar{u}_M = \frac{1}{2\mu_0} B_{\text{rms}}^2$. The intensity of the electromagnetic wave at a point, $I = c\bar{u} = c(\bar{u}_E + \bar{u}_B)$.

To answer the following questions , we assume that in case of propagation of electromagnetic wave through free space, $c = 3 \times 10^8 m.\, s^{-1}$ and $\mu_0 = 4\pi \times 10^{-7} H.\, m^{-1}$

If the electromagnetic wave propagates along x-axis, then the electric field $\overrightarrow{E}$ will be

A. along y-axis

B. along z-axis

C. on xy-plane

D. on yz-plane

Answer: D

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2. Electromagnetic waves propagate through free space or a medium as transverse waves. The electric and magnetic fields are perpendicular to each other as well as perpendicular to the direction of propagation of waves at each point. In the direction of wave propagation, electric field $\overrightarrow{E}$ and magnetic field $\overrightarrow{B}$ form a right-handed cartesian coordinate system. During the propagation of electromagnetic wave, total energy of

electromagnetic wave is distributed equally between electric and magnetic fields. Since $\in_0$ and μ_0 are permittivity and permeability of free space, the velocity of electromagnetic wave, $c = (\in_0 \mu_0)^{-1/2}$. Energy density i.e., energy in unit volume due to electric field at any point, $u_E = \frac{1}{2} \in_0 E^2$ Similarly, energy density due to magnetic field , $u_M = \frac{1}{2\mu_0} B^2$. If the electromagnetic wave propagates along x-direction, then the equations of electric and magnetic field are respectively.

$E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$

Here, the frequency and the wavelength of oscillating electric and magnetic fields are $f = \frac{\omega}{2\pi}$ and $\lambda = \frac{2\pi}{k}$ respectively. Thus $E_{\text{rms}} = \frac{E_0}{\sqrt{2}}$ and $B_{\text{rms}} = \frac{B_0}{\sqrt{2}}$, where $\frac{E_0}{B_0} = c$. Therefore, average energy density $\bar{u}_E = \frac{1}{2} \in_0 E_{\text{rms}}^2$ and $\bar{u}_M = \frac{1}{2\mu_0} B_{\text{rms}}^2$. The intensity of the electromagnetic wave at a point, $I = c\bar{u} = c(\bar{u}_E + \bar{u}_B)$.

To answer the following questions , we assume that in case of propagation of electromagnetic wave through free space,

$c = 3 \times 10^8 m.\, s^{-1}$ and $\mu_0 = 4\pi \times 10^{-7} H.\, m^{-1}$

If the peak value of electric field at a point in electromagnetic wave is 15 V . m^{-1}, then average electrical energy density (in j . m^{-3})

A. 4.48×10^{-9}

B. 9.95×10^{-9}

C. 4.98×10^{-10}

D. 9.95×10^{-10}

Answer: C

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3. Electromagnetic waves propagate through free space or a medium as transverse waves. The electric and magnetic fields are perpendicular to each other as well as perpendicular to the

direction of propagation of waves at each point. In the direction of wave propagation, electric field $\overrightarrow{E}$ and magnetic field $\overrightarrow{B}$ form a right-handed cartesian coordinate system. During the propagation of electromagnetic wave, total energy of electromagnetic wave is distributed equally between electric and magnetic fields. Since $\in_0$ and μ_0 are permittivity and permeability of free space, the velocity of electromagnetic wave, $c = (\in_0 \mu_0)^{-1/2}$. Energy density i.e., energy in unit volume due to electric field at any point, $u_E = \frac{1}{2} \in_0 E^2$ Similarly, energy density due to magnetic field , $u_M = \frac{1}{2\mu_0} B^2$. If the electromagnetic wave propagates along x-direction, then the equations of electric and magnetic field are respectively.

$E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$

Here, the frequency and the wavelength of oscillating electric and magnetic fields are $f = \frac{\omega}{2\pi}$ and $\lambda = \frac{2\pi}{k}$ respectively. Thus $E_{\text{rms}} = \frac{E_0}{\sqrt{2}}$ and $B_{\text{rms}} = \frac{B_0}{\sqrt{2}}$, where $\frac{E_0}{B_0} = c$. Therefore, average energy density $\bar{u}_E = \frac{1}{2} \in_0 E_{\text{rms}}^2$ and $\bar{u}_M = \frac{1}{2\mu_0} B_{\text{rms}}^2$.

The intensity of the electromagnetic wave at a point, $I = c\bar{u} = c(\bar{u}_E + \bar{u}_B)$.

To answer the following questions , we assume that in case of propagation of electromagnetic wave through free space, $c = 3 \times 10^8 m.\, s^{-1}$ and $\mu_0 = 4\pi \times 10^{-7} H.\, m^{-1}$

The peak value of magnetic field (in Wb . m^{-2}) at that point

A. 5×10^{-8}

B. 45×10^{-8}

C. 5×10^{8}

D. 45×10^{8}

Answer: A

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4. Electromagnetic waves propagate through free space or a medium as transverse waves. The electric and magnetic fields are perpendicular to each other as well as perpendicular to the direction of propagation of waves at each point. In the direction of wave propagation, electric field $\overrightarrow{E}$ and magnetic field $\overrightarrow{B}$ form a right-handed cartesian coordinate system. During the propagation of electromagnetic wave, total energy of electromagnetic wave is distributed equally between electric and magnetic fields. Since $\in_0$ and μ_0 are permittivity and permeability of free space, the velocity of electromagnetic wave, $c = (\in_0 \mu_0)^{-1/2}$. Energy density i.e., energy in unit volume due to electric field at any point, $u_E = \frac{1}{2} \in_0 E^2$ Similarly, energy density due to magnetic field , $u_M = \frac{1}{2\mu_0} B^2$. If the electromagnetic wave propagates along x-direction, then the equations of electric and magnetic field are respectively.

$E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$

Here, the frequency and the wavelength of oscillating electric and magnetic fields are $f = \frac{\omega}{2\pi}$ and $\lambda = \frac{2\pi}{k}$ respectively. Thus $E_{\text{rms}} = \frac{E_0}{\sqrt{2}}$ and $B_{\text{rms}} = \frac{B_0}{\sqrt{2}}$, where $\frac{E_0}{B_0} = c$. Therefore, average energy density $\bar{u}_E = \frac{1}{2} \in_0 E_{\text{rms}}^2$ and $\bar{u}_M = \frac{1}{2\mu_0} B_{\text{rms}}^2$. The intensity of the electromagnetic wave at a point, $I = c\bar{u} = c(\bar{u}_E + \bar{u}_B)$.

To answer the following questions , we assume that in case of propagation of electromagnetic wave through free space, $c = 3 \times 10^8 m.\, s^{-1}$ and $\mu_0 = 4\pi \times 10^{-7} H.\, m^{-1}$

Average energy density (in J . m^{-3})of electromagnetic wave at that point

A. 4.98×10^{-9}

B. 9.95×10^{-9}

C. 4.98×10^{-10}

D. 9.95×10^{-10}

Answer: D

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5. Electromagnetic waves propagate through free space or a medium as transverse waves. The electric and magnetic fields are perpendicular to each other as well as perpendicular to the direction of propagation of waves at each point. In the direction of wave propagation, electric field $\vec{E}$ and magnetic field $\vec{B}$ form a right-handed cartesian coordinate system. During the propagation of electromagnetic wave, total energy of electromagnetic wave is distributed equally between electric and magnetic fields. Since $\in_0$ and μ_0 are permittivity and permeability of free space, the velocity of electromagnetic wave, $c = (\in_0 \mu_0)^{-1/2}$. Energy density i.e., energy in unit volume due to electric field at any point, $u_E = \frac{1}{2} \in_0 E^2$ Similarly, energy

density due to magnetic field , $u_M = \frac{1}{2\mu_0} B^2$. If the electromagnetic wave propagates along x-direction, then the equations of electric and magnetic field are respectively.

$E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$

Here, the frequency and the wavelength of oscillating electric and magnetic fields are $f = \frac{\omega}{2\pi}$ and $\lambda = \frac{2\pi}{k}$ respectively. Thus $E_{\text{rms}} = \frac{E_0}{\sqrt{2}}$ and $B_{\text{rms}} = \frac{B_0}{\sqrt{2}}$, where $\frac{E_0}{B_0} = c$. Therefore, average energy density $\bar{u}_E = \frac{1}{2} \in_0 E_{\text{rms}}^2$ and $\bar{u}_M = \frac{1}{2\mu_0} B_{\text{rms}}^2$. The intensity of the electromagnetic wave at a point, $I = c\bar{u} = c(\bar{u}_E + \bar{u}_B)$.

To answer the following questions , we assume that in case of propagation of electromagnetic wave through free space, $c = 3 \times 10^8 m.\, s^{-1}$ and $\mu_0 = 4\pi \times 10^{-7} H.\, m^{-1}$

Intensity (in W . m^{-2}) of electromagnetic wave at that point is almost

A. 0.15

B. 0.3

C. 0.45

D. 0.6

Answer: B

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6. Electromagnetic waves propagate through free space or a medium as transverse waves. The electric and magnetic fields are perpendicular to each other as well as perpendicular to the direction of propagation of waves at each point. In the direction of wave propagation, electric field $\overrightarrow{E}$ and magnetic field $\overrightarrow{B}$ form a right-handed cartesian coordinate system. During the propagation of electromagnetic wave, total energy of electromagnetic wave is distributed equally between electric and

magnetic fields. Since $\in_0$ and μ_0 are permittivity and permeability of free space, the velocity of electromagnetic wave, $c = (\in_0 \mu_0)^{-1/2}$. Energy density i.e., energy in unit volume due to electric field at any point, $u_E = \frac{1}{2} \in_0 E^2$ Similarly, energy density due to magnetic field , $u_M = \frac{1}{2\mu_0} B^2$. If the electromagnetic wave propagates along x-direction, then the equations of electric and magnetic field are respectively.

$E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$

Here, the frequency and the wavelength of oscillating electric and magnetic fields are $f = \frac{\omega}{2\pi}$ and $\lambda = \frac{2\pi}{k}$ respectively. Thus $E_{\text{rms}} = \frac{E_0}{\sqrt{2}}$ and $B_{\text{rms}} = \frac{B_0}{\sqrt{2}}$, where $\frac{E_0}{B_0} = c$. Therefore, average energy density $\bar{u}_E = \frac{1}{2} \in_0 E_{\text{rms}}^2$ and $\bar{u}_M = \frac{1}{2\mu_0} B_{\text{rms}}^2$. The intensity of the electromagnetic wave at a point, $I = c\bar{u} = c(\bar{u}_E + \bar{u}_B)$.

To answer the following questions , we assume that in case of propagation of electromagnetic wave through free space,

$c = 3 \times 10^8 m.\, s^{-1}$ and $\mu_0 = 4\pi \times 10^{-7} H.\, m^{-1}$

if the wavelength is 1000Å, then the frequency (in Hz)

A. 10^{13}

B. 3×10^{13}

C. 10^{15}

D. 3×10^{15}

Answer: D

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7. Electromagnetic waves propagate through free space or a medium as transverse waves. The electric and magnetic fields are perpendicular to each other as well as perpendicular to the direction of propagation of waves at each point. In the direction of wave propagation, electric field $\vec{E}$ and magnetic field $\vec{B}$ form

a right-handed cartesian coordinate system. During the propagation of electromagnetic wave, total energy of electromagnetic wave is distributed equally between electric and magnetic fields. Since $\in_0$ and μ_0 are permittivity and permeability of free space, the velocity of electromagnetic wave, $c = (\in_0 \mu_0)^{-1/2}$. Energy density i.e., energy in unit volume due to electric field at any point, $u_E = \frac{1}{2} \in_0 E^2$ Similarly, energy density due to magnetic field , $u_M = \frac{1}{2\mu_0} B^2$. If the electromagnetic wave propagates along x-direction, then the equations of electric and magnetic field are respectively.

$E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$

Here, the frequency and the wavelength of oscillating electric and magnetic fields are $f = \frac{\omega}{2\pi}$ and $\lambda = \frac{2\pi}{k}$ respectively. Thus $E_{\text{rms}} = \frac{E_0}{\sqrt{2}}$ and $B_{\text{rms}} = \frac{B_0}{\sqrt{2}}$, where $\frac{E_0}{B_0} = c$. Therefore, average energy density $\bar{u}_E = \frac{1}{2} \in_0 E_{\text{rms}}^2$ and $\bar{u}_M = \frac{1}{2\mu_0} B_{\text{rms}}^2$. The intensity of the electromagnetic wave at a point, $I = c\bar{u} = c(\bar{u}_E + \bar{u}_B)$.

To answer the following questions , we assume that in case of propagation of electromagnetic wave through free space, $c = 3 \times 10^8 m.\, s^{-1}$ and $\mu_0 = 4\pi \times 10^{-7} H.\, m^{-1}$

Relation between ω and k

A. $\omega = ck$

B. $\omega = \frac{ck}{2\pi}$

C. $\omega = \frac{c}{k}$

D. $\omega = \frac{c}{2\pi k}$

Answer: A

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Entrance Corner Interger

1. If dielectric constant and relative magnetic permeability of a medium are 4 and 2.25 receptively, then the velocity of electromagnetic wave in that medium is $n \times 10^8 m.\, s^{-1}$ Find the value of n.

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2. When the frequency of an electromagnetic wave and the amplitude of its associated magnetic field at a point are 10^8 Hz and 10^{-10} T respectively, then the amplitude of electric field be $n \times 10^{-2} V.\, m^{-1}$. Find the value of n.

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3. Due to the sunlight, if the amplitude of the electric field at the earth surface is 900 V . m^{-1}, then the amplitude of the magnetic

field is $n \times 10^{-6}$ T. Find the value of n.

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4. What is wavelength (in metre) of radio wave of frequency 1.5×10^{8} Hz ?

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5. If the intensity of electromagnetic wave at a point is 0.085 W . m^{-2}, then find the average amplitude (in V. m^{-1}) of electric field at that point.

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Examination Archive

1. Electromagnetic waves are produced by -

(A) A static charge

(B) A uniformly moving charge

(C) An accelerated charge

(D) Neutral particle

A. a static charge

B. a uniformly moving charge

C. an accelerated charge

D. neutral particle

Answer: C

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2. An electromagnetic wave of frequency 25 MHz travels in free space along x-direction. At a particular point in space and time, $\vec{E} = 6.3\hat{j}$ volt/metre. What is the value and direction of $\vec{B}$ of the wave at that point?

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3. The speed of electromagnetic waves in vacuum is -

(A) $\sqrt{\in_0 \mu_0}$

(B) $1/\sqrt{\mu_0 \in_0}$

(C) $\in_0 \mu_0$

(D) $1/(\in_0 \mu_0)$

A. $\sqrt{\in_0 \mu_0}$

B. $1/\sqrt{\mu_0 \in_0}$

C. $\in_0 \mu_0$

D. $1/(\in_0 \mu_0)$

Answer: B

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4. Mention two characteristics of electromagnetic waves.

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5. What are the quantities that oscillate in an electromagnetic wave? Show by means of a diagram, the relative orientation of the directions of the electric vector, magnetic vector and propagation of the electromagnetic wave.

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6. Electromagnetic wave does not carry -

(A) Energy

(B) Charge

(C) Information

(D) Momentum

A. energy

B. charge

C. information

D. momentum

Answer: B

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7. A plane electromagnetic wave Ez = 100cos $(6 \times 10^8$ t+ 4x)V/m propagates in a medium. Find the refractive index of the medium.

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8. The electric and magnetic field of electromagnetic waves are -

(A) In opposite phase and perpendicular to each other.

(B) In opposite phase and parallel to each other.

(C) In the same phase and perpendicular to each other.

(D) In the same phase and parallel to each other.

A. in opposite phase and perpendicular to each other

B. in opposite phase and parallel to each other

C. In the same phase and perpendicular to each other

D. in the same phase and parallel to each other

Answer: C

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9. The energy of gamma (γ) ray photon is E_γ and that of an X-ray photon is E_X. If the visible light photon has an energy of E_v, then we can say that

A. $E_X > E_\gamma > E_v$

B. $E_\gamma > E_v > E_X$

C. $E_\gamma > E_X > E_v$

D. $E_X > E_v > E_\gamma$

Answer: C

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10. During the propagation of electromagnetic waves in a medium

A. electric energy density is double of the magnetic energy density

B. electric energy density is half of the magnetic energy density

C. electric energy density is equal to the magnetic energy density

D. both electric and magnetic energy densities are zero

Answer: C

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11. A red LED emits light a 0.1 watt uniformly around it. The amplitude of the electric field of the light at a distance of 1 m from the diode is

A. 1.73 V/m

B. 2.45 V/m

C. 5.48 V/m

D. 7.75 V/m

Answer: B

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12. Arrange the following electromagnetic radiations per quantum in the order of increasing energy:

(i) Blue Light (ii) Yellow Light (iii) X-Ray (iv) Radio Wave

A. (iv) < (ii) < (i) < (iii)

B. (i) < (ii) < (iv) < (iii)

C. (iii) < (i) < (ii) < (iv)

D. (ii) < (i) < (iv) < (iii)

Answer: A

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13. An EM wave from air enters a medium . The electric fields are $\vec{E}_1 = E_{01}\hat{x}\cos\left[2\pi\nu\left(\frac{z}{c} - t\right)\right]$ in air and $\vec{E}_2 = E_{02}\hat{x}\cos[k(2z - ct)]$ in medium , where the wave number k and frequency ν refer to their values in air . The medium is non-magnetic . If $\in_{r_1}$ and $\in_{r_2}$ refer to relative permittivities of air

and medium respectively , which of the following options is correct ?

A. $\frac{\in_{r_1}}{\in_{r_2}} = \frac{1}{4}$

B. $\frac{\in_{r_1}}{\in_{r_2}} = \frac{1}{2}$

C. $\frac{\in_{r_1}}{\in_{r_2}} = 4$

D. $\frac{\in_{r_1}}{\in_{r_2}} = 2$

Answer: A

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14. Out of the following options which one can be used to produce a propagating electromagnetic wave?

(A) A stationary charge.

(B) A chargeless particle

(C) An accelerating charges.

(D) A charge moving at constant velocity.

A. a stationary charge

B. a chargeless particle

C. an accelerating charges

D. a charge moving at constant velocity

Answer: C

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15. An EM wave is propagating in a medium with a velocity $\overrightarrow{v} = v\hat{i}$. The instantaneous oscillating electric field of this EM wave is along +y axis. Then the direction of oscillating magnetic field of the EM wave will be along

A. $-y$ direction

B. $+z$ direction

C. $-z$ direction

D. $-x$ direction

Answer: B

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Cbse Scanner

1. What are the directions of electric and magnetic field vectors relative to each other and relative to the direction of propagation of electromagnetic waves?

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2. The speed of an electromagnetic wave in a material medium is given by $v = \frac{1}{\sqrt{\mu \in}}$, μ being the permeability of the medium and $\in$ its permittivity. How does its frequency change?

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3. Welders wear special goggles or face masks with glass windows to protect their eyes from electromagnetic radiations.Name the radiations and write the range at their frequency

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4. A capacitor made of two parallel plates each of plate area A and separation d is being charged by an external ac source. Show

that the displacement current inside the capacitor is the same as the current charging the capacitor.

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5. To which part of the electromagnetic spectrum does a wave of frequency 3×10^{13} Hz belong?

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6. Define intensity of radiation on the basis of photon picture of light. Write its SI unit.

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7. Which one of the following electromagnetic radiations has least frequency:

UV radiations, X-rays, Microwaves

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8. How do you show that electromagnetic waves carry energy and momentum?

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9. Write the expression for the energy density of an electromagnetic wave propagating in free space.

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10. How are electromagnetic waves produced? What is the source of energy of these waves? Write mathematical expressions for electric and magnetic fields on an electromagnetic wave propagating along the z-axis. Write any two important properties of electromagnetic waves.

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11. Why does current in a steady state not flow in a capacitor connected across a battery? However momentary current does flow during charging or discharging of the capacitor. Explain.

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12. How is the speed of EM waves in vacuum determined by the electric and magnetic fields?

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13. Do electromagnetic waves carry energy and momentum?

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14. Identify the electromagnetic waves whose wavelengths vary as

(a)$10^{-12}m < \lambda < 10^{-8}m$ and (b)$10^{-3}m < \lambda < 10^{-1}$ m

Write one use for each.

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15. What do you understand by the statement, "Electromagnetic waves transport momentum"?

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16. Name the electromagnetic radiations used for

(a) Water purification

(b) Eye surgery.

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17. Why are infrared waves often called heat waves? Explain.

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