Chapter 21

Electromagnetic Waves

1. 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 **[AIEEE-2012]**

   (1) $\vec{X} \parallel \vec{E}$ and $\vec{k} \parallel \vec{E} \times \vec{B}$

   (2) $\vec{X} \parallel \vec{B}$ and $\vec{k} \parallel \vec{E} \times \vec{B}$

   (3) $\vec{X} \parallel \vec{E}$ and $\vec{k} \parallel \vec{B} \times \vec{E}$

   (4) $\vec{X} \parallel \vec{B}$ and $\vec{k} \parallel \vec{B} \times \vec{E}$

2. A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flows through the smaller loop, then the flux linked with bigger loop is **[JEE (Main)-2013]**

   (1) 9.1×10^{-11} weber (2) 6×10^{-11} weber

   (3) 3.3×10^{-11} weber (4) 6.6×10^{-9} weber

3. The magnetic field in a travelling electromagnetic wave has a peak value of 20 nT. The peak value of electric field strength is : [JEE (Main)-2013]

   (1) 3 V/m (2) 6 V/m

   (3) 9 V/m (4) 12 V/m

4. During the propagation of electromagnetic waves in a medium **[JEE (Main)-2014]**

   (1) Electric energy density is double of the magnetic energy density

   (2) Electric energy density is half of the magnetic energy density

   (3) Electric energy density is equal to the magnetic energy density

   (4) Both electric and magnetic energy densities are zero

5. Match List-I (Electromagnetic wave type) with List - II (Its association/application) and select the correct option from the choices given below the lists:

List-I		List-II	
(a)	Infrared waves	(i)	To treat muscular strain
(b)	Radio waves	(ii)	For broadcasting
(c)	X-rays	(iii)	To detect fracture of bones
(d)	Ultraviolet rays	(iv)	Absorbed by the ozone layer of the atmosphere

[JEE (Main)-2014]

	(a)	(b)	(c)	(d)
(1)	(iv)	(iii)	(ii)	(i)
(2)	(i)	(ii)	(iv)	(iii)
(3)	(iii)	(ii)	(i)	(iv)
(4)	(i)	(ii)	(iii)	(iv)

6. A red LED emits light at 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 **[JEE (Main)-2015]**

   (1) 1.73 V/m (2) 2.45 V/m

   (3) 5.48 V/m (4) 7.75 V/m

7. Arrange the following electromagnetic radiations per quantum in the order of increasing energy: **[JEE (Main)-2016]**

   A : Blue light

   B : Yellow light

   C : X-ray

   D : Radiowave

   (1) A, B, D, C

   (2) C, A, B, D

   (3) B, A, D, C

   (4) D, B, A, C

8. 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 ε_{r_1} and ε_{r_2} refer to relative permittivities of air and medium respectively, which of the following options is correct? **[JEE (Main)-2018]**

(1) $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = 4$ (2) $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = 2$

(3) $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = \frac{1}{4}$ (4) $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = \frac{1}{2}$

9. A plane electromagnetic wave of frequency 50 MHz travels in free space along the positive x-direction. At a particular point in space and time, $\vec{E} = 6.3\hat{j}$ V/m. The corresponding magnetic field $\vec{B}$, at that point will be **[JEE (Main)-2019]**

(1) $18.9\times10^{-8}\hat{k}$ T (2) $2.1\times10^{-8}\hat{k}$ T

(3) $6.3\times10^{-8}\hat{k}$ T (4) $18.9\times10^{8}\hat{k}$ T

10. The energy associated with electric field is (U_E) and with magnetic field is (U_B) for an electromagnetic wave in free space, Then **[JEE (Main)-2019]**

(1) $U_E < U_B$ (2) $U_E = \frac{U_B}{2}$

(3) $U_E = U_B$ (4) $U_E > U_B$

11. The magnetic field associated with a light wave is given, at the origin, by $B = B_0$ [sin(3.14 × 10^7)ct + sin(6.28 × 10^7)ct]. If this light falls on a silver plate having a work function of 4.7 eV, what will be the maximum kinetic energy of the photo electrons? **[JEE (Main)-2019]**

(c = 3 × 10^8 ms^{-1}, h = 6.6 × 10^{-34} J-s)

(1) 8.52 eV (2) 7.72 eV

(3) 12.5 eV (4) 6.82 eV

12. If the magnetic field of a plane electromagnetic wave is given by (The speed of light = 3 × 10^8 m/s) $B = 100\times10^{-6}\sin\left[2\pi\times2\times10^{15}\left(t-\frac{x}{c}\right)\right]$, then the maximum electric field associated with it is **[JEE (Main)-2019]**

(1) 6 × 10^4 N/C (2) 3 × 10^4 N/C

(3) 4.5 × 10^4 N/C (4) 4 × 10^4 N/C

13. The electric field of a plane polarized electromagnetic wave in free space at time t = 0 is given by an expression **[JEE (Main)-2019]**

$$\vec{E}(x,y) = 10\hat{j}\cos[(6x+8z)]$$

The magnetic field $\vec{B}$ (x, z, t) is given by

(c is the velocity of light)

(1) $\frac{1}{c}(6\hat{k}+8\hat{i})\cos[(6x+8z-10ct)]$

(2) $\frac{1}{c}(6\hat{k}-8\hat{i})\cos[(6x+8z+10ct)]$

(3) $\frac{1}{c}(6\hat{k}+8\hat{i})\cos[(6x-8z+10ct)]$

(4) $\frac{1}{c}(6\hat{k}-8\hat{i})\cos[(6x+8z-10ct)]$

14. An electromagnetic wave of intensity 50 Wm^{-2} enters in a medium of refractive index 'n' without any loss. The ratio of the magnitudes of electric fields, and the ratio of the magnitudes of magnetic fields of the wave before and after entering into the medium are respectively, given by

[JEE (Main)-2019]

(1) $\left(\frac{1}{\sqrt{n}}, \sqrt{n}\right)$ (2) $\left(\sqrt{n}, \frac{1}{\sqrt{n}}\right)$

(3) $\left(\frac{1}{\sqrt{n}}, \frac{1}{\sqrt{n}}\right)$ (4) $\left(\sqrt{n}, \sqrt{n}\right)$

15. A 27 mW laser beam has a cross-sectional area of 10 mm^2. The magnitude of the maximum electric field in this electromagnetic wave is given by

[Given permittivity of space ϵ_0 = 9 × 10^{-12} SI units, Speed of light c = 3 × 10^8 m/s] **[JEE (Main)-2019]**

(1) 1.4 kV/m (2) 1 kV/m

(3) 2 kV/m (4) 0.7 kV/m

16. A light wave is incident normally on a glass slab of refractive index 1.5. If 4% of light gets reflected and the amplitude of the electric field of the incident light is 30 V/m, then the amplitude of the electric field for the wave propogating in the glass medium will be **[JEE (Main)-2019]**

(1) 6 V/m (2) 10 V/m

(3) 24 V/m (4) 30 V/m

17. The mean intensity of radiation on the surface of the Sun is about 10^8 W/m^2. The rms value of the corresponding magnetic field is closet to

[JEE (Main)-2019]

(1) 10^2 T (2) 10^{-4} T

(3) 1 T (4) 10^{-2} T

18. In SI units, the dimensions of $\sqrt{\frac{\varepsilon_0}{\mu_0}}$ is

[JEE (Main)-2019]

(1) $AT^2M^{-1}L^{-1}$ (2) $AT^{-3}ML^{3/2}$

(3) $A^{-1}TML^3$ (4) $A^2T^3M^{-1}L^{-2}$

19. A plane electromagnetic wave travels in free space along the *x*-direction. The electric field component of the wave at a particular point of space and time is $E = 6$ Vm^{-1} along *y*-direction. Its corresponding magnetic field component, *B* would be

[JEE (Main)-2019]

(1) 2×10^{-8} T along *y*-direction

(2) 6×10^{-8} T along *z*-direction

(3) 2×10^{-8} T along *z*-direction

(4) 6×10^{-8} T along *x*-direction

20. The magnetic field of an electromagnetic wave is given by: **[JEE (Main)-2019]**

$$\vec{B} = 1.6\times10^{-6}\cos(2\times10^{7}z + 6\times10^{15}t)(2\hat{i}+\hat{j})\frac{\text{Wb}}{\text{m}^2}$$

The associated electric field will be:

(1) $\vec{E} = 4.8\times10^{2}\cos\left(2\times10^{7}z + 6\times10^{15}t\right)(-\hat{i}+2\hat{j})\frac{\text{V}}{\text{m}}$

(2) $\vec{E} = 4.8\times10^{2}\cos\left(2\times10^{7}z - 6\times10^{15}t\right)(2\hat{i}+\hat{j})\frac{\text{V}}{\text{m}}$

(3) $\vec{E} = 4.8\times10^{2}\cos\left(2\times10^{7}z - 6\times10^{15}t\right)(-2\hat{j}+\hat{i})\frac{\text{V}}{\text{m}}$

(4) $\vec{E} = 4.8\times10^{2}\cos\left(2\times10^{7}z + 6\times10^{15}t\right)(\hat{i}-2\hat{j})\frac{\text{V}}{\text{m}}$

21. The magnetic field of a plane electromagnetic wave is given by

$\vec{B} = \vec{B}_0\hat{i}$ [cos(*kz* − ω*t*) + $B_1\hat{j}$ cos(*kz* + ω*t*)

where $B_0 = 3 \times 10^{-5}$ T and $B_1 = 2 \times 10^{-6}$ T

The rms value of the force experienced by a stationary charge $Q = 10^{-4}$ C at $z = 0$ is closest to **[JEE (Main)-2019]**

(1) 0.6 N (2) 0.9 N

(3) 3×10^{-2} N (4) 0.1 N

22. The electric field of a plane electromagnetic wave is given by

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

The corresponding magnetic field $\vec{B}$ is then given by : **[JEE (Main)-2019]**

(1) $\vec{B} = \frac{E_0}{C}\hat{j}\ \sin(kz)\cos(\omega t)$

(2) $\vec{B} = \frac{E_0}{C}\hat{j}\ \cos(kz)\sin(\omega t)$

(3) $\vec{B} = \frac{E_0}{C}\hat{j}\ \sin(kz)\sin(\omega t)$

(4) $\vec{B} = \frac{E_0}{C}\hat{k}\ \sin(kz)\cos(\omega t)$

23. An electromagnetic wave is represented by the electric field

$\vec{E} = E_0\hat{n}\sin[\omega t + (6y - 8z)]$. Taking unit vectors in *x*, *y* and *z* directions to be $\hat{i}, \hat{j}, \hat{k},$ the direction of propogation $\hat{s}$, is : **[JEE (Main)-2019]**

(1) $\hat{s} = \left(\frac{-3\hat{j}+4\hat{k}}{5}\right)$ (2) $\hat{s} = \left(\frac{3\hat{i}-4\hat{j}}{5}\right)$

(3) $\hat{s} = \left(\frac{-4\hat{k}+3\hat{j}}{5}\right)$ (4) $\hat{s} = \left(\frac{4\hat{j}-3\hat{k}}{5}\right)$

24. Which of the following combinations has the dimension of electrical resistance (ε_0 is the permittivity of vacuum and μ_0 is the permeability of vacuum)? **[JEE (Main)-2019]**

(1) $\sqrt{\frac{\varepsilon_0}{\mu_0}}$ (2) $\frac{\varepsilon_0}{\mu_0}$

(3) $\sqrt{\frac{\mu_0}{\varepsilon_0}}$ (4) $\frac{\mu_0}{\varepsilon_0}$

25. A plane electromagnetic wave having a frequency ν = 23.9 GHz propagates along the positive *z*-direction in free space. The peak value of the electric field is 60 V/m. Which among the following is the acceptable magnetic field component in the electromagnetic wave? **[JEE (Main)-2019]**

(1) $\vec{B} = 60\sin(0.5\times10^3 x + 1.5\times10^{11} t)\hat{k}$

(2) $\vec{B} = 2\times10^7 \sin(0.5\times10^3 z + 1.5\times10^{11} t)\hat{i}$

(3) $\vec{B} = 2\times10^{-7} \sin(0.5\times10^3 z - 1.5\times10^{11} t)\hat{i}$

(4) $\vec{B} = 2\times10^{-7} \sin(1.5\times10^2 x + 0.5\times10^{11} t)\hat{j}$

26. If the magnetic field in a plane electromagnetic wave is given by

$\vec{B} = 3\times10^{-8}\sin(1.6\times10^3 x + 48\times10^{10} t)\hat{j}$ T,

then what will be expression for electric field?

[JEE (Main)-2020]

(1) $\vec{E} = \left(60\sin(1.6\times10^3 x + 48\times10^{10} t)\hat{k}\text{ V/m}\right)$

(2) $\vec{E} = \left(3\times10^{-8}\sin(1.6\times10^3 x + 48\times10^{10} t)\hat{i}\text{ V/m}\right)$

(3) $\vec{E} = \left(9\sin(1.6\times10^3 x + 48\times10^{10} t)\hat{k}\text{ V/m}\right)$

(4) $\vec{E} = \left(3\times10^{-8}\sin(1.6\times10^3 x + 48\times10^{10} t)\hat{j}\text{ V/m}\right)$

27. The electric field of a plane electromagnetic wave is given by

$\vec{E} = E_0 \dfrac{\hat{i}+\hat{j}}{\sqrt{2}}\cos(kz + \omega t)$

At t = 0, a positively charged particle is at the point (x, y, z) = $\left(0, 0, \dfrac{\pi}{k}\right)$. If its instantaneous velocity at (t = 0) is $v_0\hat{k}$, the force acting on it due to the wave is **[JEE (Main)-2020]**

(1) Antiparallel to $\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}$

(2) Zero

(3) Parallel to $\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}$

(4) Parallel to $\hat{k}$

28. A plane electromagnetic wave of frequency 25 GHz is propagating in vacuum along the z-direction. At a particular point in space and time, the magnetic field is given by $\vec{B} = 5\times10^{-8}\hat{j}$ T. The corresponding electric field $\vec{E}$ is (speed of light c = 3 × 10^8 ms^{-1}) **[JEE (Main)-2020]**

(1) $-1.66\times10^{-16}\hat{i}$ V/m

(2) $1.66\times10^{-16}\hat{i}$ V/m

(3) $-15\,\hat{i}$ V/m

(4) $15\,\hat{i}$ V/m

29. The electric fields of two plane electromagnetic plane waves in vacuum are given by

$\vec{E}_1 = E_0\,\hat{j}\cos(\omega t - kx)$ and

$\vec{E}_2 = E_0\hat{k}\cos(\omega t - ky)$

At t = 0, a particle of chcarge q is at origin with a velocity $\vec{v} = 0.8\,c\hat{j}$ (c is the speed of light in vaccum). The instantaneous force experienced by the particle is **[JEE (Main)-2020]**

(1) $E_0 q(0.4\hat{i} - 3\hat{j} + 0.8\hat{k})$

(2) $E_0 q(-0.8\hat{i} + \hat{j} + \hat{k})$

(3) $E_0 q(0.8\hat{i} + \hat{j} + 0.2\hat{k})$

(4) $E_0 q(0.8\hat{i} - \hat{j} + 0.4\hat{k})$

30. A plane electromagnetic wave is propagating along the direction $\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}$, with its polarization along the direction $\hat{k}$. The correct form of the magnetic field of the wave would be (here B_0 is an appropriate constant) **[JEE (Main)-2020]**

(1) $B_0\dfrac{\hat{i}-\hat{j}}{\sqrt{2}}\cos\left(\omega t - k\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(2) $B_0\hat{k}\cos\left(\omega t - k\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(3) $B_0\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}\cos\left(\omega t - k\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(4) $B_0\dfrac{\hat{j}-\hat{i}}{\sqrt{2}}\cos\left(\omega t + k\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

31. A plane electromagnetic wave, has frequency of 2.0 × 10^{10} Hz and its energy density is 1.02 × 10^{-8} J/m^3 in vacuum. The amplitude of the magnetic field of the wave is close to ($\dfrac{1}{4\pi\varepsilon_0} = 9\times10^9\dfrac{Nm^2}{C^2}$ and speed of light = 3 × 10^8 ms^{-1}) **[JEE (Main)-2020]**

(1) 190 nT (2) 160 nT

(3) 150 nT (4) 180 nT

32. In a plane electromagnetic wave, the directions of electric field and magnetic field are represented by $\hat{k}$ and $2\hat{i}-2\hat{j}$, respectively. What is the unit vector along direction of propagation of the wave? **[JEE (Main)-2020]**

(1) $\frac{1}{\sqrt{5}}(\hat{i}+2\hat{j})$ (2) $\frac{1}{\sqrt{2}}(\hat{j}+\hat{k})$

(3) $\frac{1}{\sqrt{2}}(\hat{i}+\hat{j})$ (4) $\frac{1}{\sqrt{5}}(2\hat{i}+\hat{j})$

33. The electric field of a plane electromagnetic wave propagating along the x direction in vacuum is $\vec{E} = E_0\hat{j}\cos(\omega t - kx)$. The magnetic field $\vec{B}$, at the moment $t = 0$ is **[JEE (Main)-2020]**

(1) $\vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos(kx)\hat{j}$

(2) $\vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos(kx)\hat{k}$

(3) $\vec{B} = \frac{E_0}{\sqrt{\mu_0\varepsilon_0}}\cos(kx)\hat{k}$

(4) $\vec{B} = \frac{E_0}{\sqrt{\mu_0\varepsilon_0}}\cos(kx)\hat{j}$

34. Choose the correct option relating wavelengths of different parts of electromagnetic wave spectrum **[JEE (Main)-2020]**

(1) $\lambda_{\text{x-rays}} < \lambda_{\text{micro waves}} < \lambda_{\text{radio waves}} < \lambda_{\text{visible}}$

(2) $\lambda_{\text{visible}} > \lambda_{\text{x-rays}} > \lambda_{\text{radio waves}} > \lambda_{\text{micro waves}}$

(3) $\lambda_{\text{radio waves}} > \lambda_{\text{micro waves}} > \lambda_{\text{visible}} > \lambda_{\text{x-rays}}$

(4) $\lambda_{\text{visible}} < \lambda_{\text{micro waves}} < \lambda_{\text{radio waves}} < \lambda_{\text{x-rays}}$

35. The electric field of a plane electromagnetic wave is given by **[JEE (Main)-2020]**

$$\vec{E} = E_0(\hat{x}+\hat{y})\sin(kz-\omega t)$$

Its magnetic field will be given by

(1) $\frac{E_0}{c}(\hat{x}-\hat{y})\cos(kz-\omega t)$

(2) $\frac{E_0}{c}(\hat{x}-\hat{y})\sin(kz-\omega t)$

(3) $\frac{E_0}{c}(-\hat{x}+\hat{y})\sin(kz-\omega t)$

(4) $\frac{E_0}{c}(\hat{x}-\hat{y})\sin(kz-\omega t)$

36. The quantities $x = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$, $y = \frac{E}{B}$ and $z = \frac{l}{CR}$ are defined where C-capacitance, R-Resistance, l-length, E-Electric field, B-magnetic field and ε_0, μ_0, - free space permittivity and permeability respectively. Then **[JEE (Main)-2020]**

(1) Only x and y have the same dimension

(2) Only x and z have the same dimension

(3) x, y and z have the same dimension

(4) Only y and z have the same dimension

37. The correct match between the entries in column I and column II are **[JEE (Main)-2020]**

I		II	
Radiation		**Wavelength**	
(a)	Microwave	(i)	100 m
(b)	Gamma rays	(ii)	10^{-15} m
(c)	A.M. radio waves	(iii)	10^{-10} m
(d)	X = rays	(iv)	10^{-3} m

(1) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)

(2) (a)-(iv), (b)-(ii), (c)-(i), (d)-(iii)

(3) (a)-(iii), (b)-(ii), (c)-(i), (d)-(iv)

(4) (a)-(i), (b)-(iii), (c)-(iv), (d)-(ii)

38. The magnetic field of a plane electromagnetic wave is **[JEE (Main)-2020]**

$$\vec{B} = 3\times10^{-8}\sin[200\pi(y+ct)]\hat{i}\,T$$

where $c = 3 \times 10^8$ ms^{-1} is the speed of light.

The corresponding electric field is

(1) $\vec{E} = -9\sin[200\pi(y+ct)]\hat{k}$ V/m

(2) $\vec{E} = 9\sin[200\pi(y+ct)]\hat{k}$ V/m

(3) $\vec{E} = -10^{-6}\sin[200\pi(y+ct)]\hat{k}$ V/m

(4) $\vec{E} = 3\times10^{-8}\sin[200\pi(y+ct)]\hat{k}$ V/m

39. For a plane electromagnetic wave, the magnetic field at a point x and time t is **[JEE (Main)-2020]**

$$\vec{B}(x,t) = [1.2\times10^{-7}\sin(0.5\times10^3x+1.5\times10^{11}t)\hat{k}]\text{T}.$$

The instantaneous electric field $\vec{E}$ corresponding to $\vec{B}$ is

(speed of light $c = 3 \times 10^8$ ms^{-1})

(1) $\vec{E}(x,t) = \left[36\sin(1\times10^3 x + 1.5\times10^{11}t)\hat{i}\right]\frac{V}{m}$

(2) $\vec{E}(x,t) = \left[36\sin(0.5\times10^3 x + 1.5\times10^{11}t)\hat{k}\right]\frac{V}{m}$

(3) $\vec{E}(x,t) = \left[-36\sin(0.5\times10^3 x + 1.5\times10^{11}t)\hat{j}\right]\frac{V}{m}$

(4) $\vec{E}(x,t) = \left[36\sin(1\times10^3 x + 0.5\times10^{11}t)\hat{j}\right]\frac{V}{m}$

40. A beam of electromagnetic radiation of intensity 6.4×10^{-5}W/cm^2 is comprised of wavelength, $\lambda = 310$ nm. It falls normally on a metal (work function $\varphi = 2$ eV) of surface area of 1 cm^2. If one in 10^3 photons ejects an electron, total number of electrons ejected in 1 s is 10^x. ($hc = 1240$ eVnm, 1 eV = 1.6×10^{-19} J), then x is _______.

[JEE (Main)-2020]

41. Suppose that intensity of a laser is $\left(\frac{315}{\pi}\right)$ W/m^2. The rms electric field, in units of V/m associated with this source is close to the nearest integer is ______. **[JEE (Main)-2020]**

($\varepsilon_0 = 8.86 \times 10^{-12}$ C^{2}Nm^{-2}; $c = 3 \times 10^8$ ms^{-1})

42. An electromagnetic wave of frequency 5 GHz, is travelling in a medium whose relative electric permittivity and relative magnetic permeability both are 2. Its velocity in this medium is _________ × 10^7 m/s. **[JEE (Main)-2021]**

43. Match List-I with List-II.

	List-I		**List-II**
(a)	Source of microwave frequency	(i)	Radioactive decay of nucleus
(b)	Source of infrared frequency	(ii)	Magnetron
(c)	Source of Gamma Rays	(iii)	Inner shell electrons
(d)	Source of X-rays	(iv)	Vibration of atoms and molecules
		(v)	LASER
		(vi)	RC circuit

Choose the correct answer from the options given below : **[JEE (Main)-2021]**

(1) (a)-(ii), (b)-(iv), (c)-(vi), (d)-(iii)

(2) (a)-(vi), (b)-(v), (c)-(i), (d)-(iv)

(3) (a)-(vi), (b)-(iv), (c)-(i), (d)-(v)

(4) (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)

44. An electromagnetic wave of frequency 3 GHz enters a dielectric medium of relative electric permittivity 2.25 from vacuum. The wavelength of this wave in that medium will be ______× 10^{-2} cm. **[JEE (Main)-2021]**

45. The peak electric field produced by the radiation coming from the 8 W bulb at a distance of 10 m is $\frac{x}{10}\sqrt{\frac{\mu_0 c}{\pi}}\frac{V}{m}$. Bulb is considered to be a point source. The value of x is ________.

[JEE (Main)-2021]

46. A radiation is emitted by 1000 W bulb and it generates an electric field and magnetic field at P, placed at a distance of 2 m. The efficiency of the bulb is 1.25%. The value of peak electric field at P is x × 10^{-1} V/m. Value of x is ________. (Rounded-off to the nearest integer)

[Take $\varepsilon_0 = 8.85\times10^{-12}\text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}, \text{c} = 3\times10^8 \text{ms}^{-1}$]

[JEE (Main)-2021]

47. A plane electromagnetic wave of frequency 500 MHz is travelling in vacuum along y-direction. At a particular point in space and time, $\vec{B} = 8.0\times10^{-8}\hat{z}$T. The value of electric field at this point is :

(speed of light = 3×10^8 ms^{-1})

$\hat{x}, \hat{y}, \hat{z}$ are unit vectors along x, y and z directions.

[JEE (Main)-2021]

(1) $-24\ \hat{x}$ V/m (2) $2.6\ \hat{x}$ V/m

(3) $24\ \hat{x}$ V/m (4) $-2.6\ \hat{y}$ V/m

48. For an electromagnetic wave travelling in free space, the relation between average energy densities due to electric (U_e) and magnetic (U_m) fields is: **[JEE (Main)-2021]**

(1) $U_e > U_m$ (2) $U_e = U_m$

(3) $U_e \neq U_m$ (4) $U_e < U_m$

49. Red light differs from blue light as they have: **[JEE (Main)-2021]**

(1) Different frequencies and same wavelengths

(2) Same frequencies and different wavelengths

(3) Same frequencies and same wavelengths

(4) Different frequencies and different wavelengths

50. If 2.5×10^{-6} N of average force is exerted by a light wave on a non-reflecting surface of 30 cm^2 area during 40 minutes of time span, the energy flux of light just before it falls on the surface is W/cm^2. (Round off to the Nearest Integer)

(Assume complete adsorption and normal incidence conditions are there)

[JEE (Main)-2021]

51. Seawater at a frequency $f = 9 \times 10^2$ Hz, has permittivity $\varepsilon = 80\varepsilon_0$ and resistivity $\rho = 0.25\ \Omega$m. Imagine a parallel plate capacitor is immersed in seawater and is driven by an alternating voltage source $V(t) = V_0 \sin(2\pi ft)$. Then the conduction current density becomes 10^x times the displacement current density after time $t = \frac{1}{800}$ s. The value of x is ________.

$$\left(\text{Given}: \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{Nm}^2\text{C}^{-2}\right)$$

[JEE (Main)-2021]

52. The electric field intensity produced by the radiation coming from a 100 W bulb at a distance of 3 m is E. The electric field intensity produced by the radiation coming from 60 W at the same distance is $\sqrt{\frac{x}{5}}E$. Where the value of x = ________.

[JEE (Main)-2021]

53. A plane electromagnetic wave of frequency 100 MHz is travelling in vacuum along the x-direction. At a particular point in space and time, $\vec{B} = 2.0 \times 10^{-8}\,\hat{k}\,T$. (where, $\hat{k}$ is unit vector along z-direction) What is $\vec{E}$ at this point?

(speed of light $c = 3 \times 10^8$ m/s)

[JEE (Main)-2021]

(1) $6.0\hat{j}$ V/m

(2) $0.6\hat{j}$ V/m

(3) $0.6\hat{k}$ V/m

(4) $6.0\hat{k}$ V/m

54. A plane electromagnetic wave propagating along y-direction can have the following pair of electric field $(\vec{E})$ and magnetic field $(\vec{B})$ components.

[JEE (Main)-2021]

(1) E_x, B_z or E_z, B_x

(2) E_x, B_y or E_y, B_x

(3) E_y, B_y or E_z, B_z

(4) E_y, B_x or E_x, B_y

55. In an electromagnetic wave the electric field vector and magnetic field vector are given as $\vec{E} = E_0\hat{i}$ and $\vec{B} = B_0\hat{k}$ respectively. The direction of propagation of electromagnetic wave is along:

[JEE (Main)-2021]

(1) $(-\hat{k})$

(2) $(-\hat{j})$

(3) $\hat{j}$

(4) $(\hat{k})$

56. Intensity of sunlight is observed as 0.092 Wm^{-2} at a point in free space. What will be the peak value of magnetic field at the point?

($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2N^{-1}m^{-2}$) **[JEE (Main)-2021]**

(1) 2.77×10^{-8} T

(2) 1.96×10^{-8} T

(3) 8.31 T

(4) 5.88 T

57. A linearly polarized electromagnetic wave in vacuum is **[JEE (Main)-2021]**

$$E = 3.1\cos[(1.8)z - (5.4 \times 10^6)t]\hat{i}\ \text{N/C}$$

is incident normally on a perfectly reflecting wall at $z = a$. Choose the correct option

(1) The frequency of electromagnetic wave is 54×10^4 Hz.

(2) The reflected wave will be

$$3.1\cos[(1.8)z + (5.4 \times 10^6)t]\hat{i}\ \text{N/C}$$

(3) The transmitted wave will be

$$3.1\cos[(1.8)z - (5.4 \times 10^6)t]\hat{i}\ \text{N/C}$$

(4) The wavelength is 3.5 units (approx.)

58. The relative permittivity of distilled water is 81. The velocity of light in it will be

(Given $\mu_r = 1$) **[JEE (Main)-2021]**

(1) 2.33×10^7 m/s

(2) 3.33×10^7 m/s

(3) 5.33×10^7 m/s

(4) 4.33×10^7 m/s

59. A light beam is described by $E = 800\sin\omega\left(t - \frac{x}{c}\right)$.

An electron is allowed to move normal to the propagation of light beam with a speed of 3×10^7 ms^{-1}. What is the maximum magnetic force exerted on the electron? **[JEE (Main)-2021]**

(1) 1.28×10^{-21} N (2) 1.28×10^{-18} N

(3) 12.8×10^{-18} N (4) 12.8×10^{-17} N

60. Electric field in a plane electromagnetic wave is given by $E = 50\sin(500x - 10 \times 10^{10}t)$ V/m

The velocity of electromagnetic wave in this medium is:

(Given C = speed of light in vacuum)

[JEE (Main)-2021]

(1) $\frac{C}{2}$ (2) $\frac{2}{3}C$

(3) $\frac{3}{2}C$ (4) C

61. A plane electromagnetic wave with frequency of 30 MHz travels in free space. At particular point in space and time, electric field is 6 V/m. The magnetic field at this point will be $x \times 10^{-8}$ T. The value of x is _______. **[JEE (Main)-2021]**

62. The electric field in an electromagnetic wave is given by $E = (50\ NC^{-1})\sin\omega(t - x/c)$

The energy contained in a cylinder of volume V is 5.5×10^{-12} J. The value of V is ___ cm^3.

(given $\varepsilon_0 = 8.8 \times 10^{-12}\ C^2N^{-1}\ m^{-2}$)

[JEE (Main)-2021]

63. The magnetic field vector of an electromagnetic wave is given by $B = B_0\frac{\hat{i}+\hat{j}}{\sqrt{2}}\cos(kz - \omega t)$; where $\hat{i}, \hat{j}$ represents unit vector along x and y-axis respectively. At t = 0 s, two electric charges q_1 of 4π coulomb and q_2 of 2π coulomb located at $\left(0, 0, \frac{\pi}{k}\right)$ and $\left(0, 0, \frac{3\pi}{k}\right)$, respectively, have the same velocity of 0.5 c $\hat{i}$, (where c is the velocity of light). The ratio of the force acting on charge q_1 to q_2 is: **[JEE (Main)-2021]**

(1) $\sqrt{2} : 1$ (2) 2 : 1

(3) $2\sqrt{2} : 1$ (4) $1 : \sqrt{2}$

64. Electric field of a plane electromagnetic wave propagating through a non-magnetic medium is given by $E = 20\cos(2 \times 10^{10}\ t - 200x)$ V/m. The dielectric constant of the medium is equal to:

(Take $\mu_r = 1$) **[JEE (Main)-2021]**

(1) $\frac{1}{3}$

(2) 9

(3) 3

(4) 2

65. A plane electromagnetic waves travels in a medium of relative permeability 1.61 and relative permittivity 6.44. If magnitude of magnetic intensity is $4.5 \times 10^{-2}\ Am^{-1}$ at a point, what will be the approximate magnitude of electric field intensity at that point?

(Given : Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ NA^{-2}, speed of light in vacuum $c = 3 \times 10^8\ ms^{-1}$)

[JEE (Main)-2022]

(1) 16.96 Vm^{-1}

(2) $2.25 \times 10^{-2}\ Vm^{-1}$

(3) 8.48 Vm^{-1}

(4) $6.75 \times 10^6\ Vm^{-1}$

66. The electric field in an electromagnetic wave is given by $E = 56.5\sin\omega(t - x/c)\ NC^{-1}$. Find the intensity of the wave if it is propagating along x-axis in the free space.

(Given $\epsilon_0 = 8.85 \times 10^{-12} C^2N^{-1}m^{-2}$)

[JEE (Main)-2022]

(1) 5.65 Wm^{-2}

(3) 4.24 Wm^{-2}

(3) $1.9 \times 10^{-7}\ Wm^{-2}$

(4) 56.5 Wm^{-2}

67. The electromagnetic waves travel in a medium at a speed of 2.0×10^8 m/s. The relative permeability of the medium is 1.0. The relative permittivity of the medium will be **[JEE (Main)-2022]**

(1) 2.25 (2) 4.25

(3) 6.25 (4) 8.25

68. If electric field intensity of a uniform plane electro magnetic wave is given as

$$E = -301.6\sin(kz-\omega t)\hat{a}_x + 452.4\sin(kz-\omega t)\hat{a}_y \frac{V}{m}.$$

Then, magnetic intensity 'H' of this wave in Am^{-1} will be :

[Given : Speed of light in vacuum $c = 3 \times 10^8$ ms^{-1}, Permeability of vacuum $\mu_0 = 4\pi \times 10^{-7}$ NA^{-2}]

[JEE (Main)-2022]

(1) $+0.8\sin(kz-\omega t)\hat{a}_y + 0.8\sin(kz-\omega t)\hat{a}_x$.

(2) $+1.0\times10^{-6}\sin(kz-\omega t)\hat{a}_y + 1.5\times10^{-6}$ $(kz-\omega t)\hat{a}_x$

(3) $-0.8\sin(kz-\omega t)\hat{a}_y - 1.2\sin(kz-\omega t)\hat{a}_x$

(4) $-1.0\times10^{-6}\sin(kz-\omega t)\hat{a}_y - 1.5\times10^{-6}$ $\sin(kz-\omega t)\hat{a}_x$

69. Match List-I with List-II **[JEE (Main)-2022]**

	List-I		**List-II**
(a)	Ultraviolet rays	(i)	Study crystal structure
(b)	Microwaves	(ii)	Greenhouse effect
(c)	Infrared waves	(iii)	Sterilizing surgical instrument
(d)	X-rays	(iv)	Radar system

Choose the **correct** answer from the options given below :

(1) (a)-(iii), (b)-(iv), (c)-(ii), (d)-(i)

(2) (a)-(iii), (b)-(i), (c)-(ii), (d)-(iv)

(3) (a)-(iv), (b)-(iii), (c)-(ii), (d)-(i)

(4) (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)

70. Given below are two statements:

Statement I: A time varying electric field is a source of changing magnetic field and vice-versa. Thus a disturbance in electric or magnetic field creates *EM* waves.

Statement II: In a material medium, the *EM* wave travels with speed $v = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$.

In the light of the above statements, choose the correct answer from the options given below.

[JEE (Main)-2022]

(1) Both statement I and statement II are true

(2) Both statement I and statement II are false

(3) Statement I is correct but statement II is false

(4) Statement I is incorrect but statement II is true

71. A radar sends an electromagnetic signal of electric field (E_0) = 2.25 V/m and magnetic field (B_0) = 1.5×10^{-8} T which strikes a target on line of sight at a distance of 3 km in a medium. After that, a part of signal (echo) reflects back towards the radar with same velocity and by same path. If the signal was transmitted at time $t = 0$ from radar, then after how much time echo will reach to the radar?

[JEE (Main)-2022]

(1) 2.0×10^{-5} s (2) 4.0×10^{-5} s

(3) 1.0×10^{-5} s (4) 8.0×10^{-5} s

72. An EM wave propagating in *x*-direction has a wavelength of 8 mm. The electric field vibrating *y*-direction has maximum magnitude of 60 Vm^{-1}. Choose the correct equations for electric and magnetic field if the EM wave is propagating in vacuum:

[JEE (Main)-2022]

(1) $E_y = 60\sin\left[\frac{\pi}{4}\times10^3\left(x-3\times10^8 t\right)\right]\hat{j}$ Vm^{-1}

$B_z = 2\sin\left[\frac{\pi}{4}\times10^3\left(x-3\times10^8 t\right)\right]\hat{k}$ T

(2) $E_y = 60\sin\left[\frac{\pi}{4}\times10^3\left(x-3\times10^8 t\right)\right]\hat{j}$ Vm^{-1}

$B_z = 2\times10^{-7}\sin\left[\frac{\pi}{4}\times10^3\left(x-3\times10^8 t\right)\right]\hat{k}$ T

(3) $E_y = 2\times10^{-7}\sin\left[\frac{\pi}{4}\times10^3\left(x-3\times10^8 t\right)\right]\hat{j}$ Vm^{-1}

$B_z = 60\sin\left[\frac{\pi}{4}\times10^3\left(x-3\times10^8 t\right)\right]\hat{k}$ T

(4) $E_y = 2\times10^{-7}\sin\left[\frac{\pi}{4}\times10^4\left(x-4\times10^8 t\right)\right]\hat{j}\,\text{Vm}^{-1}$

$B_z = 60\sin\left[\frac{\pi}{4}\times10^4\left(x-4\times10^8 t\right)\right]\hat{k}\,\text{T}$

73. The intensity of the light from a bulb incident on a surface is 0.22 W/m^2. The amplitude of the magnetic field in this light-wave is ___ × 10^{-9} T.

(Given : Permittivity of vacuum ε_0 = 8.85 × 10^{-12} C^2 N^{-1}–m^{-2}, speed of light in vacuum c = 3 × 10^8 ms^{-1}) **[JEE (Main)-2022]**

74. The displacement current of 4.425 μA is developed in the space between the plates of parallel plate capacitor when voltage is changing at a rate of 10^6 Vs^{-1}. The area of each plate of the capacitor is 40 cm^2. The distance between each plate of the capacitor x × 10^{-3} m. The value of x is,

(Permittivity of free space, E_0 = 8.85 × 10^{-12} C^2 N^{-1} m^{-2}) **[JEE (Main)-2022]**

75. Light wave traveling in air along x-direction is given by E_y = 540 sin π × 10^4 ($x - ct$)Vm^{-1}. Then, the peak value of magnetic field of wave will be

(Given c = 3 × 10^8 ms^{-1}) **[JEE (Main)-2022]**

(1) 18 × 10^{-7} T

(2) 54 × 10^{-7} T

(3) 54 × 10^{-8} T

(4) 18 × 10^{-8} T

76. The magnetic field of a plane electromagnetic wave is given by

$\vec{B} = 2\times10^{-8}\sin(0.5\times10^3 x + 1.5\times10^{11} t)\hat{j}\,\text{T}$

The amplitude of the electric field would be

[JEE (Main)-2022]

(1) 6 Vm^{-1} along x-axis

(2) 3 Vm^{-1} along z-axis

(3) 6 Vm^{-1} along z-axis

(4) 2 × 10^{-8} Vm^{-1} along z-axis

77. A beam of light travelling along X-axis is described by the electric field E_y = 900sin ω($t - x/c$). The ratio of electric force to magnetic force on a charge q moving along Y-axis with a speed of 3 × 10^7 ms^{-1} will be :
(Given speed of light = 3 × 10^8 ms^{-1})

[JEE (Main)-2022]

(1) 1 : 1
(2) 1 : 10
(3) 10 : 1
(4) 1 : 2

78. Identify the correct statements from the following descriptions of various properties of electromagnetic waves. **[JEE (Main)-2022]**

(A) In a plane electromagnetic wave electric field and magnetic field must be perpendicular to each other and direction of propagation of wave should be along electric field or magnetic field.

(B) The energy in electromagnetic wave is divided equally between electric and magnetic fields.

(C) Both electric field and magnetic field are parallel to each other and perpendicular to the direction of propagation of wave.

(D) The electric field, magnetic field and direction of propagation of wave must be perpendicular to each other.

(E) The ratio of amplitude of magnetic field to the amplitude of electric field is equal to speed of light.

Choose the **most appropriate** answer from the options given below

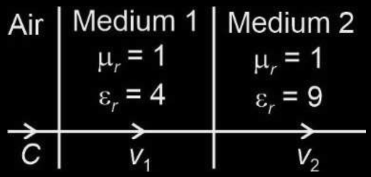
(1) (D) only

(2) (B) and (D) only

(3) (B), (C) and (E) only

(4) (A), (B) and (E) only

79. As shown in the figure, after passing through the medium 1. The speed of light v_2 in medium 2 will be: (Given $c = 3 \times 10^8$ ms^{-1}) **[JEE (Main)-2022]**



(1) 1.0×10^8 ms^{-1}

(2) 0.5×10^8 ms^{-1}

(3) 1.5×10^8 ms^{-1}

(4) 3.0×10^8 ms^{-1}

80. The oscillating magnetic field in a plane electromagnetic wave is given by

$B_y = 5 \times 10^{-6} \sin 1000\pi(5x - 4 \times 10^8 t)$T.

The amplitude of electric field will be:

[JEE (Main)-2022]

(1) 15×10^2 Vm^{-1}

(2) 5×10^{-6} Vm^{-1}

(3) 16×10^{12} Vm^{-1}

(4) 4×10^2 Vm^{-1}

81. Which is the correct ascending order of wavelengths?

[JEE (Main)-2022]

(1) $\lambda_{\text{visible}} < \lambda_{\text{X-ray}} < \lambda_{\text{gamma-ray}} < \lambda_{\text{microwave}}$

(2) $\lambda_{\text{gamma-ray}} < \lambda_{\text{X-ray}} < \lambda_{\text{visible}} < \lambda_{\text{microwave}}$

(3) $\lambda_{\text{X-ray}} < \lambda_{\text{gamma-ray}} < \lambda_{\text{visible}} < \lambda_{\text{microwave}}$

(4) $\lambda_{\text{microwave}} < \lambda_{\text{visible}} < \lambda_{\text{gamma-ray}} < \lambda_{\text{X-ray}}$

82. For a specific wavelength 670 nm of light from a galaxy moving with velocity v, the observed wavelength is 670.7 nm.

The value of v is: **[JEE (Main)-2022]**

(1) 3×10^8 ms^{-1}

(2) 3×10^{10} ms^{-1}

(3) 3.13×10^5 ms^{-1}

(4) 4.48×10^5 ms^{-1}

❑ ❑ ❑

Chapter 21

Electromagnetic Waves

1. Answer (1)
2. Answer (1)

By the principle of reversibility, we can take the same current through the bigger coil and calculate the flux through smaller coil.

$$B = \frac{\mu_0}{4\pi} \times \frac{2 \times i\pi R^2}{(R^2 + x^2)^{3/2}}$$

$$= \frac{10^{-7} \times 2 \times 2 \times \pi \times (20 \times 10^{-2})^2}{[(20 \times 10^{-2})^2 + (15 \times 10^{-2})^2]^{3/2}}$$

$$= \frac{10^{-7} \times 2 \times 2 \times \pi \times 4 \times 10^{-2}}{(25 \times 10^{-2})^3}$$

$= 1.024\pi \times 10^{-6}$ T

$\phi = 1.024\pi \times 10^{-6} \times \pi(0.3 \times 10^{-2})^2$

$= 9.1 \times 10^{-11}$ weber

3. Answer (2)

$\frac{E}{B} = c \;\Rightarrow E = cB = 3 \times 10^8 \times 20 \times 10^{-9} = 6$ V/m

4. Answer (3)

Energy is equally divided between electric and magnetic field

5. Answer (4)

(a) Infrared rays are used to treat muscular strain

(b) Radiowaves are used for broadcasting

(c) X-rays are used to detect fracture of bones

(d) Ultraviolet rays are absorbed by ozone

6. Answer (2)

$$I = \frac{P}{4\pi r^2} = U_{av} \times c \qquad \text{...(i)}$$

$$U_{av} = \frac{1}{2}\varepsilon_0 E_0^2 \qquad \text{...(ii)}$$

$$\Rightarrow \frac{P}{4\pi r^2} = \frac{1}{2}\varepsilon_0 E_0^2 \times c$$

$$\Rightarrow E_0 = \sqrt{\frac{2P}{4\pi r^2 \varepsilon_0 c}} = 2.45 \text{ V/m}$$

7. Answer (4)

According to electromagnetic spectrum D, B, A, C

8. Answer (3)

$$\vec{E}_1 = E_{01}\hat{x}\cos\left[2\pi\nu\left(\frac{z}{c} - t\right)\right] \qquad \text{air}$$

$$\vec{E}_2 = E_{02}\hat{x}\cos[k(2z - ct)] \qquad \text{medium}$$

During refraction, frequency remains unchanged, whereas wavelength gets changed.

$\therefore\; k' = 2k$ (From equations)

$$\Rightarrow \frac{2\pi}{\lambda'} = 2\left(\frac{2\pi}{\lambda_0}\right)$$

$$\Rightarrow \lambda' = \frac{\lambda_0}{2}$$

$$\Rightarrow v = \frac{c}{2}$$

$$\Rightarrow \frac{1}{\sqrt{\mu_0\varepsilon_2}} = \frac{1}{2} \times \frac{1}{\sqrt{\mu_0\varepsilon_1}}$$

$$\Rightarrow \frac{\varepsilon_1}{\varepsilon_2} = \frac{1}{4}$$

9. Answer (2)

$$\vec{B} = \left|\frac{\vec{E}}{c}\right|\hat{k}$$

$$= \frac{6.3}{3 \times 10^8}\hat{k}$$

$$= 2.1 \times 10^{-8}\hat{k}$$

10. Answer (3)

$$U_E = \frac{1}{2}\varepsilon_0 E^2$$

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

$$\frac{U_E}{U_B} = \frac{E^2}{B^2}\varepsilon_0\mu_0$$

$$\frac{U_E}{U_B} = c^2\,\varepsilon_0\mu_0$$

$$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

11. Answer (2)

Maximum angular frequency = 6.28 × 10^7 × 3 × 10^8 rad/s

$\Rightarrow$ f_{max} = 3 × 10^{15} Hz

$$E_{max} = h\,f_{max} = \frac{6.6\times10^{-34}\times3\times10^{15}}{1.6\times10^{-19}}\ \text{eV}$$

$$= 12.375\ \text{eV} \simeq 12.38\ \text{eV}$$

$\Rightarrow$ KE_{max} = 12.38 –4.7 ≃ 7.7 eV

12. Answer (2)

$E_m = CB_m$ = 3 × 10^8 × 100 × 10^{-6} = 3×10^4 N/C

13. Answer (4)

$$\vec{E}.\vec{B} = 0$$

$\Rightarrow$ $\vec{B}$ is in xz plane

$\vec{E}\times\vec{B}$ is parallel to $\left(6\hat{i} + 8\hat{k}\right)$

let $\vec{B} = \left(x\hat{i} + z\hat{k}\right)$

then, $\hat{j}\times\left(x\hat{i} + z\hat{k}\right) = 6\hat{i} + 8\hat{k}$

$\Rightarrow$ z = 6 and x = –8

$\therefore$ $\vec{B} = \frac{1}{C}\left(6\hat{k} - 8\hat{i}\right)$ cos (6x + 8z – 10ct)

14. Answer (2)

$$C = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

$$V = \frac{1}{\sqrt{k\varepsilon_0\mu_0}}$$

$$\frac{C}{V} = \sqrt{k} = n$$

$$\frac{1}{2}\varepsilon_0 E_0^2 C = \frac{1}{2}\varepsilon_0 k E^2 V$$

$$\frac{E_0}{E} = \sqrt{n}$$

Similarly,

$$\frac{B_0}{B} = \frac{1}{\sqrt{n}}$$

15. Answer (1)

$$\frac{1}{2}\varepsilon_0 E_0^2 = I$$

$$I = \frac{P}{Ac}$$

$$E_0^2\times\frac{1}{2}\times9\times10^{-12} = \frac{27\times10^{-3}}{A\times3\times10^8}$$

$$E_0^2 = \frac{9\times10^{-8}\times2\times10^{-3}}{9\times10^{-12}\times10^{-5}}$$

$$E_0^2 = 2\times10^6$$

E_0 = 1.4 × 10^3 V/m

= 1.4 kV/m

16. Answer (3)

$$v = \frac{1}{\sqrt{\varepsilon\mu_0}},\quad c = \frac{1}{\sqrt{\varepsilon_0\mu_0}}$$

$$\Rightarrow \frac{v}{c} = \sqrt{\frac{\varepsilon_0}{\varepsilon_0}}$$

$$I_2 = \frac{1}{2}\varepsilon E_2^2\times v$$

$$I_1 = \frac{1}{2}\varepsilon_0 E_1^2\times c$$

$$\Rightarrow \frac{I_2}{I_1} = \frac{\varepsilon}{\varepsilon_0}\times\frac{E_2^2}{E_1^2}\times\frac{v}{c}$$

$$\Rightarrow 0.96 = \frac{c^2}{v^2}\times\frac{E_2^2}{E_1^2}\times\frac{v}{c}$$

$$\Rightarrow \frac{0.96}{\mu}\times E_1^2 = E_2^2$$

$$\Rightarrow E_2 = \sqrt{\frac{0.96}{1.5}}\times E_0$$

= 0.8 × (30)

= 24 V/m

17. Answer (2)

$$\frac{B_0^2}{2\mu_0} = \frac{10^8}{c}$$

$$B_0 = \frac{2\times10^8\times4\pi\times10^{-7}}{3\times10^8}$$

$$B_{rms} = \frac{B_0}{\sqrt{2}}$$

out of given option, option (2) is correct.

18. Answer (4)

$$\left[\sqrt{\frac{\varepsilon_0}{\mu_0}}\right] = \left[\frac{\varepsilon_0}{\sqrt{\mu_0\varepsilon_0}}\right] = [LT^{-1}]\times[\varepsilon_0]$$

$$\because \quad F = \frac{q^2}{4\pi\varepsilon_0 r^2}$$

$$\Rightarrow \quad [\varepsilon_0] = \frac{[AT]^2}{[MLT^{-2}]\times[L^2]}$$

$$\therefore \quad \left[\sqrt{\frac{\varepsilon_0}{\mu_0}}\right] = [LT^{-1}]\times[A^2M^{-1}L^{-3}T^4]$$

$$= [M^{-1}L^{-2}T^3A^2]$$

19. Answer (3)

$$B_0 = \frac{E_0}{c} = \frac{6}{3\times10^8} = 2\times10^{-8}\ \text{T}$$

Propagation direction = $\hat{E}\times\hat{B}$

$$\hat{i} = \hat{j}\times\hat{B}$$

$$\Rightarrow \quad \hat{B} = \hat{k}$$

20. Answer (1)

Amplitude of electric field, $E = B_0C$

$$= 1.6\times10^{-6}\times\sqrt{5}\times3\times10^8$$

$$= 4.8\times10^2\sqrt{5}\ \text{V/m}$$

Also, $\vec{E}\times\vec{B}$ is along $-\hat{k}$ (the direction of propagation)

$$\Rightarrow \vec{E} = 4.8\times10^2\cos(2\times10^7 z + 6\times10^{15}t)(-\hat{i}+2\hat{j})\frac{\text{V}}{\text{m}}$$

21. Answer (1)

$$|\vec{E}_1| = CB_1$$

$$|\vec{E}_2| = CB_2$$

Also, $\vec{E}_1 \perp E_2$

$$F_{net} = \frac{\theta}{\sqrt{2}}\sqrt{E_1^2+E_2^2}$$

$$= \frac{10^{-4}}{\sqrt{2}}\times3\times10^8\times30\times10^{-6}$$

$$= \frac{90\times10^8\times10^{-10}}{\sqrt{2}}$$

$$\simeq 0.6\ \text{N}$$

22. Answer (3)

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

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

Given that $\vec{E} = E_0\cos(kz)\cos(\omega t)\hat{i}$

$$\vec{E} = \frac{E_0}{2}\left[\cos(kz-\omega t)\hat{i} - \cos(kz+\omega t)\hat{i}\right]$$

Correspondingly

$$\vec{B} = \frac{B_0}{2}\left[\cos(kz-\omega t)\hat{j} - \cos(kz+\omega t)\hat{j}\right]$$

$$\vec{B} = \frac{B_0}{2}\times2\sin kz\ \sin\omega t$$

$$\vec{B} = \left(\frac{E_0}{C}\sin kz\sin\omega t\right)\hat{j}$$

23. Answer (1)

$$E = E_0\sin(\omega t + 6y - 8z)$$

$$\hat{s} = \frac{8\hat{k}-6\hat{j}}{10} = \left(\frac{4\hat{k}-3\hat{j}}{5}\right)$$

24. Answer (3)

As we know t = RC

$$t = \frac{L}{R}$$

$$R^2\frac{C}{L} = 1$$

$$R = \sqrt{\frac{L}{C}} = \sqrt{\frac{\mu_0}{\varepsilon_0}}$$

25. Answer (3)

$$B_0 = \frac{E_0}{c} = \frac{60}{3\times10^8} = 2\times10^{-7}\ \text{T}$$

$\nu = 23.9\times10^9$ Hz

$\therefore \quad \omega = 2\pi\nu = 2\times3.142\times23.9\times10^9$

$= 1.5\times10^{11}\ \text{s}^{-1}$

$$\because \quad c = \frac{\omega}{k} \quad \Rightarrow \quad k = \frac{\omega}{c} = \frac{1.5\times10^{11}}{3\times10^8}$$

$= 0.5\times10^3$

$$\therefore \quad \vec{B} = 2\times10^{-7}\sin(0.5\times10^3 z - 1.5\times10^{11}t)\hat{i}$$

26. Answer (3)

$$\vec{B} = 3\times10^{-8}\sin\left(1.6\times10^{3}x + 48\times10^{10}t\right)\hat{j}\ \text{T}$$

$$E_0 = B_0\times C = 3\times10^{-8}\times3\times10^{8} = 9\ \text{V/m}$$

$$\therefore\ \vec{E} = 9\sin\left(1.6\times10^{3}x + 48\times10^{10}t\right)\hat{k}\ \text{V/m}$$

27. Answer (1)

$\vec{E}$ at t = 0 at z = πk is given by

$$\vec{E} = \frac{E_0}{\sqrt{2}}(\hat{i}+\hat{j})\cos[\pi] = -\frac{E_0}{\sqrt{2}}(\hat{i}+\hat{j})$$

$$\vec{F}_E = q\vec{E}$$

$\Rightarrow$ Force due to electric field, $\vec{F}_E$ is antiparallel to

$\frac{\hat{i}+\hat{j}}{\sqrt{2}}$.

$$\vec{F}_{\text{mag}} = q(\vec{v}\times\vec{B})$$

$\vec{B}$ (at t = 0, z = πk) is $\frac{B_0}{\sqrt{2}}(-\hat{i}+\hat{j})$

$\Rightarrow$ $\vec{F}_{\text{mag}} = q\ v_0\hat{k}\times\frac{B_0}{\sqrt{2}}(-\hat{i}+\hat{j})$ which is antiparallel

to $\frac{(\hat{i}+\hat{j})}{\sqrt{2}}$

$\Rightarrow$ $\vec{F}_{\text{net}} = \vec{F}_E + \vec{F}_B$ is Antiparallel to $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

28. Answer (4)

$$\vec{E} = \vec{B}\times\vec{C}$$

$\therefore$ |E| = |B| $\cdot$ C

$\Rightarrow$ $|\vec{E}| = 5\times10^{-8}\times3\times10^{8} = 15$ N/C

$$\vec{E} = 15\hat{i}\ \text{V/m}$$

29. Answer (3)

$$\vec{F} = q\vec{E} + q(\vec{V}\times\vec{B})$$

$$\vec{B}_1 = \frac{E_0}{c}\hat{k}\cos(\omega t - kx)\ \&\ \vec{B}_2 = \frac{E_0}{c}\hat{i}\cos(\omega t - ky)$$

$$\vec{F} = q(\vec{E}_1 + \vec{E}_2) + q\vec{v}\times(\vec{B}_1\times\vec{B}_2)$$

If t = 0 and x = y = 0

$$\vec{F} = qE_0(0.8\hat{i} + \hat{j} + 0.2\hat{k})$$

30. Answer (1)

$$\vec{E}\,.\,\vec{B} = 0$$

$\vec{E}\times\vec{B}$ is along $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

31. Answer (2)

$$\frac{B^2}{2\mu_0} = 1.02\times10^{-8}$$

$\Rightarrow$ $B^2 = (1.02\times10^{-8})\times2\ \mu_0$

Also, $\frac{1}{\sqrt{\mu_0\varepsilon_0}} = C \ \Rightarrow\ \mu_0 = \frac{1}{C^2\varepsilon_0}$

$\Rightarrow$ $B^2 = (1.02\times10^{-8})2\times\frac{4\pi\times9\times10^{9}}{9\times10^{16}}$

$\Rightarrow$ B $\simeq$ 160 nT

32. Answer (3)

$$\hat{C} = \hat{E}\times\hat{B}$$

$$= \hat{k}\times\frac{(\hat{i}-\hat{j})}{\sqrt{2}}$$

$$= \left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$$

33. Answer (2)

$$\vec{E}\times\vec{B}\ ||\ \vec{C}$$

Hence, $\hat{B}$ should be in $\hat{k}$ direction.

Also, $E_0 = B_0C,\ C = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

$\Rightarrow$ $\vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos kx\ \hat{k}$

34. Answer (3)

Theoretical

35. Answer (3)

$\vec{E}\times\vec{B}$ is along $\vec{C}$

$\hat{E}\times\hat{B}=\hat{C}$

$$\Rightarrow \quad \vec{B}=\frac{E_0}{C}(-\hat{x}+\hat{y})\sin(kz-\omega t)$$

36. Answer (3)

$$C=\frac{1}{\sqrt{\mu_0\varepsilon_0}}=X$$

$$C=\frac{E}{B}=Y$$

τ = RC = t

$\Rightarrow$ [X] = [Y] = [Z]

37. Answer (2)

Theory based

38. Answer (1)

$$\vec{B}=3\times10^{-8}\sin\left[200\pi(y+ct)\right]\hat{i}\ \text{ T}$$

$\Rightarrow$ Wave is travelling along –y direction with $\vec{B}$ pointing along x-axis

$$E_0=cB_0=9\ \frac{\text{V}}{\text{m}}$$

$\vec{E}\times\vec{B}$ gives direction of propagation of wave, so $\vec{\mathbf{E}}$ must be along –z axis.

$$\vec{E}=9\sin\left[200\pi(y+ct)\right]\left(-\hat{k}\right)\frac{\text{V}}{\text{m}}$$

39. Answer (3)

$\vec{B}$ = 1.2 × 10^{-7} sin(0.5 × 10^3x + 1.5 × 10^{11}t) $\hat{k}$ T.

Wave is travelling along –x axis and $\vec{B}$ is along +z axis.

$$E_0 = cB_0 = 36\ \frac{\text{V}}{\text{m}}$$

$\vec{\mathbf{E}}$ must be along –y axis

40. Answer (11.00)

$$E=\frac{hc}{\lambda}=\frac{1240}{310}PV=4eV>\phi_0$$

$$N=\frac{6.4\times10^{-5}}{4\times1.6\times10^{-19}}s^{-1}=10^{14}\text{ per sec}$$

$\therefore$ Photoelectrons/s = $\dfrac{N}{10^3}=10^{11}$

41. Answer (194)

$\because$ I = $\dfrac{1}{2}\varepsilon_0 E_0^2$ c

$$\Rightarrow E_0=\sqrt{\frac{2I}{\varepsilon_0 c}}$$

$$\therefore E_{rms}=\frac{E_0}{\sqrt{2}}=\sqrt{\frac{I}{\varepsilon_0 c}}$$

$$=\sqrt{\frac{315}{\pi}\times\frac{1}{8.86\times10^{-12}\times3\times10^8}}$$

= 194

42. Answer (15)

$$n=\sqrt{\mu_r\varepsilon_r}=2$$

$$v=\frac{c}{n}=\frac{3\times10^8}{2}=15\times10^7\text{ m/s}$$

43. Answer (4)

Source of Gamma Rays is radioactive decay source X-Ray is transition of inner shell electron and that of microwave is magnetron.

44. Answer (667)

Assuming relative permeability of the medium to be 1.

$$n=\sqrt{\mu_r\varepsilon_r}=1.5$$

$$u=\frac{c}{n}=2\times10^8\text{m/s}$$

$$\lambda=\frac{u}{f}=\frac{2\times10^8}{3\times10^9}\text{ m}$$

= 666.67 × 10^{-2} cm

45. Answer (2)

$$I = \frac{P}{4\pi r^2} = \frac{1}{2}\varepsilon_0 E_0^2 \cdot c$$

$$E_0 = \left(\frac{P}{2\pi\varepsilon_0 c r^2}\right)^{\frac{1}{2}}$$

$$\Rightarrow \quad E_0 = \frac{2}{10}\sqrt{\frac{\mu_0 c}{\pi}}\,\frac{N}{C}$$

46. Answer (137)

$$I = \frac{\eta P}{4\pi r^2} = \frac{1}{2}\varepsilon_0 E_0^2 \cdot c$$

$$= \frac{0.0125 \times 1000}{4 \times 3.14 \times 2^2} = \frac{1}{2} \times 8.85 \times 10^{-12} \times 3 \times 10^8\ E_0^2$$

$$\Rightarrow \quad E_0 = 13.69 \text{ V/m}$$

47. Answer (1)

$\vec{E}.\vec{B} = 0$

$\vec{E} \times \vec{B}$ is along positive y-direction

$$\frac{|\vec{E}|}{|\vec{B}|} = 3 \times 10^8 \text{m/s}$$

48. Answer (2)

$U_e = U_m$

49. Answer (4)

$\because$ $\lambda\nu = c$ = constant

$\therefore$ Red light and blue light have different frequencies and different wavelengths.

50. Answer (25)

$$F = \frac{I}{c}\text{A}$$

$$I = \frac{2.5 \times 10^{-6} \times 3 \times 10^8}{30}\ \frac{\text{W}}{\text{cm}^2} = 25$$

51. Answer (6)

$$i_c = \frac{V_0}{R}\sin \omega t$$

$$i_d = k\,\varepsilon_0 \frac{d}{dt}\left(\frac{v_0}{d}\sin \omega t \text{ A}\right)$$

$$= \frac{k\,\varepsilon_0\,A}{d}\, v_0 \omega \cos \omega t$$

$$= k\omega C v_0 \cos\omega t$$

$$\frac{j_c}{j_d} = \frac{i_c/A}{i_d/A} = \frac{\tan \omega t}{k\omega RC} = \frac{1}{80 \times 2\pi \times 900 \times \frac{1}{4} \times \varepsilon_0}$$

$$= 10^6$$

52. Answer (3)

$$I = \frac{P}{4\pi r^2} = \frac{E_0^2}{2\mu_0 C}$$

$$E_0 \propto \frac{\sqrt{P}}{r}$$

$$E_2 = E_1\sqrt{\frac{P_2}{P_1}} = E_0\sqrt{\frac{3}{5}}$$

53. Answer (1)

$|E_0| = |B_0| c$

$\Rightarrow$ $|E_0| = 2 \times 10^{-8} \times 3 \times 10^8$ V/m

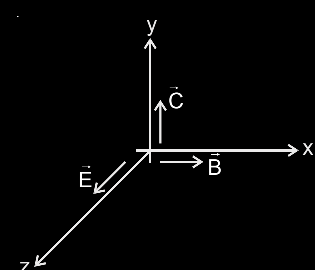
$\Rightarrow$ $|E_0|$ = 6 V/m

$\vec{S} = \vec{E} \times \vec{B}$

$\Rightarrow$ Electric field vector at given point of time should point toward positive y-axis.

54. Answer (1)

$\vec{E} \times \vec{B}$ points along $\vec{C}$



55. Answer (2)

Direction of propagation of wave = Direction of $\vec{E} \times \vec{B}$

= Direction of $E_0\hat{i} \times B_0\hat{k}$

= Direction of $E_0 B_0(-\hat{j})$

$= -\hat{j}$

56. Answer (1)

$$\frac{I}{C} = \frac{1}{2}\varepsilon_0 . E_0^2$$

$$\Rightarrow \quad E_0 = \sqrt{\frac{2I}{C\varepsilon_0}}$$

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

$$\Rightarrow \quad B_0 = \sqrt{\frac{2I}{\varepsilon_0 C^3}} = \sqrt{\frac{2 \times 0.092}{8.85 \times 10^{-12} \times 27 \times 10^{+24}}}$$

$= 2.77 \times 10^{-8}$ T

57. Answer (4)

$$E = 3.1\cos\left[5.4\times 10^6 t - 1.8z\right]\hat{i} \text{ N/C}$$

Since it is reflected by $z = a$, so z will be replaced by $(2a - z)$ also there would be phase change of π.

$$E_r = 3.1\cos\left[5.4\times 10^6 t - 1.8(2a - z) + \pi\right]\hat{i}$$

$$E_r = -3.1\cos\left[5.4\times 10^6 t + 1.8z - 3.6a\right]\hat{i}$$

Answer is dependent on a so none of option matches.

$$k = \frac{2\pi}{\lambda} \Rightarrow \lambda = \frac{2\pi}{1.8} \simeq 3.5 \text{ units}$$

58. Answer (2)

$$v = \frac{c}{\sqrt{\mu_r \varepsilon_r}} = \frac{3\times 10^8 \text{ m/s}}{\sqrt{1\times 81}}$$

$$= \frac{1}{3}\times 10^8 \text{ m/s}$$

$= 3.33 \times 10^7$ m/s

59. Answer (3)

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

$$F = e(\vec{v}\times\vec{B})$$

$$= \frac{eE}{c}\cdot v$$

$$= \frac{1.6\times 10^{-19}\times 800}{10}$$

$= 1280 \times 10^{-20}$

$= 1.28 \times 10^{-17}$ N

60. Answer (2)

$E = 50 \sin (500 - 10 \times 10^{10}\, t)$ V/m

$\omega = 10 \times 10^{10}$

$k = 500$

We know

$$v = \frac{\omega}{k} = \frac{10\times 10^{10}}{500} = \frac{1000}{500}\times 10^8$$

$= 2 \times 10^8$

$$= \frac{2}{3}(3\times 10^8)$$

$$= \frac{2}{3}C$$

61. Answer (2)

$|E| = E_0 \sin(\omega t + \phi)$

$|B| = B_0 \sin(\omega t + \phi)$

$$\frac{|B|}{|E|} = \frac{B_0}{E_0} = \frac{1}{C}$$

$|B| = 2 \times 10^{-8}$ T

62. Answer (500)

Energy U = Energy density × V

$$5.5\times 10^{-12} = \frac{1}{2}\varepsilon_0 E_0^2 \times V$$

$$V = \frac{5.5\times 10^{-12}\times 2}{8.8\times 10^{-12}\times 2500} \text{m}^3 = 500 \text{ cm}^3$$

63. Answer (2)

At given positions value of $\vec{E}$ and $\vec{B}$ is same

Force on 1 = $4\pi\left(\vec{E} + \vec{V}\times\vec{B}\right)$

Force on 2 = $2\pi\left(\vec{E} + \vec{V}\times\vec{B}\right)$

So $\dfrac{\text{Force on 1}}{\text{Force on 2}} = 2 : 1$

64. Answer (2)

Speed of light in medium $= \dfrac{2\times 10^{10}}{200}$

$= 10^8$ m/s

$$= \frac{c}{3}$$

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

$$V = \sqrt{\frac{1}{\mu\varepsilon}}$$

$$\Rightarrow \quad 3 = \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$$

$\Rightarrow$ Dielectric constant = 9

65. Answer (3)

$H = 4.5 \times 10^{-2}$

So $B = m_0 m H$

Thus $E = \frac{c}{n}B$ (where $n \Rightarrow$ refractive index)

So $E = \frac{3\times10^{8}\times4\pi\times10^{-7}\times1.61\times4.5\times10^{-2}}{\sqrt{1.61\times6.44}}$

$E = 8.48$

66. Answer (2)

$I = \frac{1}{2}\varepsilon_0 E_0^2 c$

$= \frac{1}{2}8.5\times10^{-12}\times(56.5)^2\times3\times10^{8}$

$= 4.24$ W/m^2

67. Answer (1)

$n = \frac{c}{v} = \frac{3}{2}$

$\sqrt{\in\mu} = n$

So $\in = \frac{9}{4} = 2.25$

68. Answer (3)

We know

$\vec{B}\times\vec{C} = \vec{E}$

Taking cross product of $\vec{C}$ both the sides

$\vec{C}\times(\vec{B}\times\vec{C}) = \vec{C}\times\vec{E}$

So $\vec{B} = \frac{\vec{C}\times\vec{E}}{C^2}$

$\vec{C} = C\hat{k}$

$\vec{E} = -301.6\sin(kz-\omega t)\hat{a}_x + 452.4\sin(kz-\omega t)\hat{a}_y$

and $\vec{H} = \frac{\vec{B}}{\mu_0}$

On solving

$\vec{H} = -0.8\sin(kz-\omega t)\vec{a}_y - 1.2\sin(kz-\omega t)\vec{a}_x$

69. Answer (1)

UV rays are used to sterilize surgical material. Microwaves are used in radar system, infrared are used for green house effect and X-rays are used to study crystal structure.

70. Answer (3)

In a material medium speed of light is given by $v = \frac{1}{\sqrt{\varepsilon_0\varepsilon_r\mu_0\mu_r}}$. So statement 2 is false.

71. Answer (2)

$E_0 = 2.25$ V/m

$B_0 = 1.5 \times 10^{-8}$ T

$\Rightarrow \frac{E_0}{B_0} = 1.5\times10^{8}$ m/s

$\Rightarrow$ Refractive index = 2

Distance to be travelled = 6 km

Time taken = $\frac{6\times10^{3}}{1.5\times10^{8}} = 4\times10^{-5}$ s

$\Rightarrow$ Option (B) is correct

72. Answer (2)

In first 3 options speed of light is 3×10^8 m/sec and in the fourth option it is 4×10^8 m/sec.

Using

E = CB

We can check the option is B.

73. Answer (43)

$I = \frac{1}{2}\varepsilon_0 E_0^2\cdot c = \frac{1}{2}\varepsilon_0(cB_0)^2 c$

$\Rightarrow I = \frac{1}{2}\varepsilon_0 c^3 B_0^2$

$\Rightarrow 0.22 = \frac{1}{2}\left(8.85\times10^{-12}\right)\left(3\times10^{8}\right)^3 B_0^2$

$\Rightarrow B_0 \simeq 43\times10^{-9} T$

74. Answer (8)

$$4.425\ \mu A = \frac{E_0 A}{d} \times \frac{dV}{dt}$$

$$\Rightarrow \quad d = \frac{8.85 \times 10^{-12} \times 40 \times 10^{-4}}{4.425 \times 10^{-6}} \times 10^{6}$$

$\Rightarrow$ d = 8 × 10^{-3} m

$\Rightarrow$ x = 8

75. Answer (1)

c = 3 × 10^8 m/sec

$$B = \frac{E}{c} = \frac{540}{3 \times 10^8} = 18 \times 10^{-7}\ \text{T}$$

76. Answer (3)

Speed of light $c = \frac{\omega}{k} = \frac{1.5 \times 10^{11}}{0.5 \times 10^3} = 3 \times 10^8$ m/sec

So, $E_0 = B_0 c$

= 2 × 10^{-8} × 3 × 10^8

= 6 V/m

Direction will be along z-axis

77. Answer (C)

$$\text{Ratio} = \frac{|q\vec{E}|}{|q\vec{v} \times \vec{B}|}$$

$$= \frac{E}{vB} = \frac{v_{\text{wave}}}{v}$$

$$\Rightarrow \quad \text{Ratio} = \frac{3 \times 10^8}{3 \times 10^7} = 10$$

78. Answer (B)

In an EM wave :

1. $\vec{E} \perp \vec{B}$

2. $\vec{V} \equiv \vec{E} \times \vec{B}$

3. Energy is equally divided

4. $|\vec{V}| = |\vec{E}| / |\vec{B}|$

79. Answer (A)

$$V = \frac{1}{\sqrt{\mu\varepsilon}} = \frac{1}{\sqrt{\mu_r \varepsilon_r \mu_0 \varepsilon_0}}$$

$$\Rightarrow \quad V_2 = \frac{c}{\sqrt{9}} = 10^8\ \text{m/s}$$

80. Answer (4)

Speed of light

$$c = \frac{\omega}{k} = \frac{4 \times 10^8}{5} = 0.8 \times 10^8\ \text{m/sec}$$

So $E_0 = cB_0$

= 0.8 × 10^8 × 5 × 10^{-6}

= 400 V/m

= 4 × 10^{-2}

81. Answer (2)

Wavelength of microwave is maximum then visible light then X-rays and then gamma rays so the correct order will be

$\lambda_{\text{gamma-ray}} < \lambda_{\text{X-ray}} < \lambda_{\text{visible}} < \lambda_{\text{microwave}}$

82. Answer (3)

$$\lambda_{\text{obs}} = \lambda_{\text{source}} \sqrt{\frac{1 + \frac{\nu}{C}}{1 - \frac{\nu}{C}}}$$

For $\nu << C$,

$$\frac{670.7}{670} = 1 + \frac{\nu}{C}$$

$$\Rightarrow \nu = \frac{0.7}{670} \times 3 \times 10^8\ \text{m/s}$$

$$\Rightarrow \nu \simeq 3.13 \times 10^5\ \text{m/s}$$

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