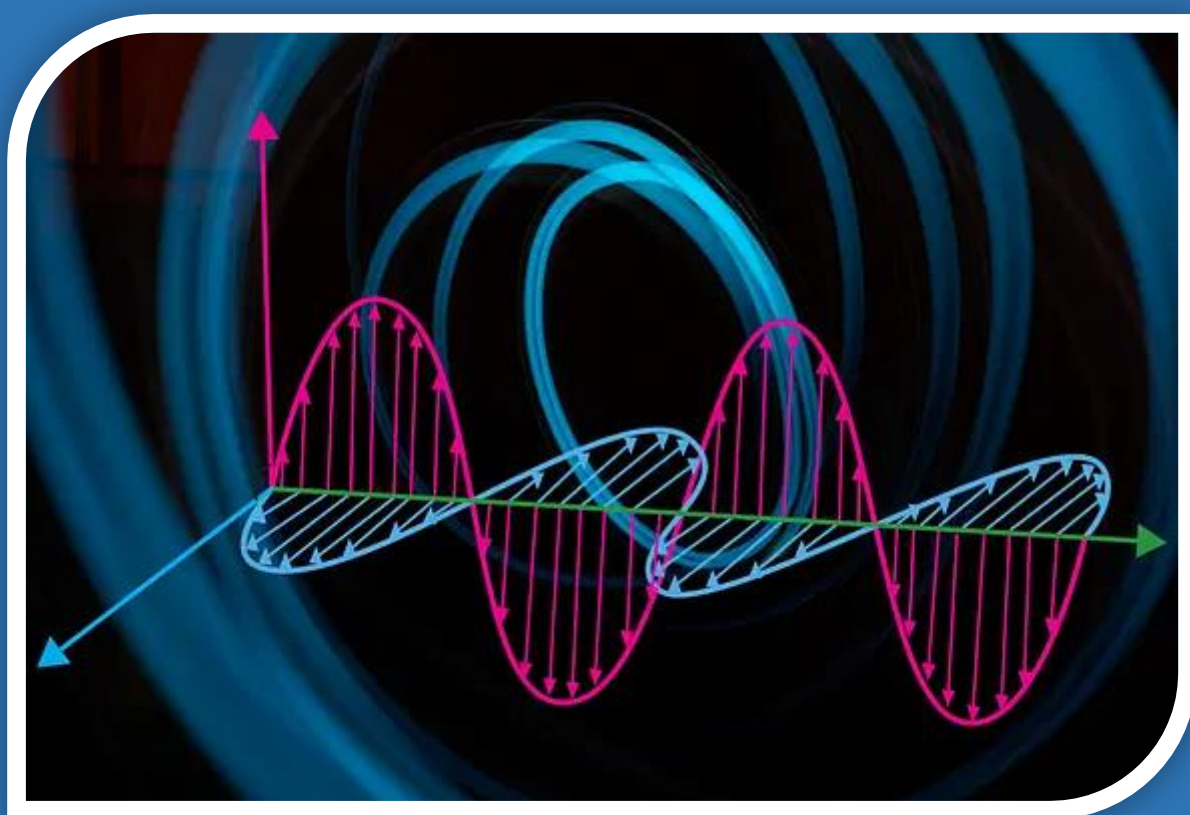


8.ELECTROMAGNETIC WAVES



**Ramanujan School of Mathematics
and Physics**

**Theory + NCERT MCQs + Topic Wise
Practice MCQs + NEET PYQs**

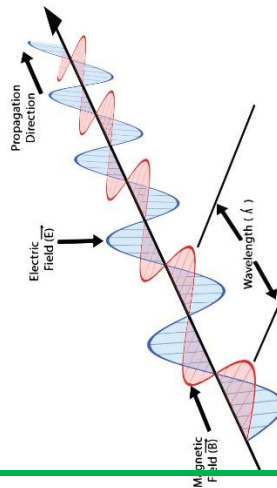
EM waves

Electromagnetic waves

Generation of EM waves

1. Em waves are created as a result of vibrations between an electric field and a magnetic field.
2. Directions of propagation of wave is perpendicular to the direction of magnetic and electric field.

Electromagnetic Wave



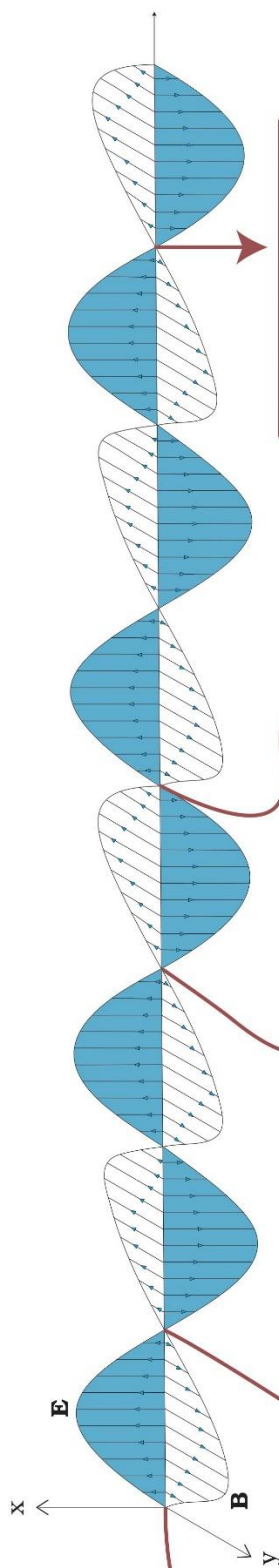
Characteristics

1. Transverse in nature.
2. Do not require any medium for propagation.
3. Produced by accelerated charge.
4. Travels with speed of light in free space.

$$C = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3 \times 10^8 \text{ m/s}$$

5. $\vec{E}$ and $\vec{B}$ are in same phase.
6. In free space,

$$\frac{|\vec{E}|}{|\vec{B}|} = c \quad (\text{Speed of light in vacuum})$$



Maxwell's Equations

GAUSS'S LAW IN Electrostatic
 $\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$

GAUSS'S LAW IN magnetism
 $\oint \vec{B} \cdot d\vec{A} = 0$

GAUSS'S LAW IN Electromagnetic Induction
 $\text{emf} = \oint \vec{E} \cdot d\vec{l} = \frac{d\Phi_B}{dt}$

Maxwell-Ampere's Circuital Law
 $\oint \vec{B} \cdot d\vec{l} = \mu_0 i_c + \mu_0 \epsilon_0 \frac{d\phi_E}{dt}$

Displacement Current

Current produced due to time varying electric field.

$$I_D = \epsilon_0 \frac{d\phi}{dt} = \epsilon_0 A \left(\frac{dE}{dt} \right)$$

$\phi = \text{electric flux}$
 $E = \text{electric field}$

Ampere circuital Law.

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$$

Net current passing through Amperian loop. This law only consider current passing through the wire but it did not consider the current flux generated due to variation of electric flux or electric field with time.

Energy density of wave

For electric field

$$U_E = \frac{1}{4} \epsilon_0 E^2$$

For magnetic field

$$U_B = \frac{1}{4} \mu_0 B^2$$

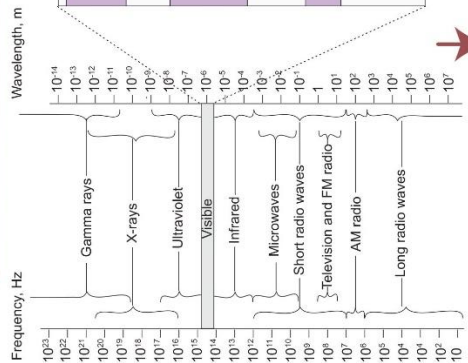
$$\Rightarrow U_{\text{average}} = \frac{1}{4} \epsilon_0 E_0^2 + \frac{1}{4} \mu_0 B_0^2$$

Intensity of EM waves

Intensity is the energy crossing per second per unit area perpendicular to direction of propagation of EM waves.

$$I = \frac{1}{2} \epsilon_0 E_0^2 C$$

Electromagnetic wave spectrum



Different types of Electromagnetic wave

TYPES	WAVELENGTH RANGE	PRODUCTION
Radio waves	Greater than	Rapid accelerations and decelerations of electrons in aerials.
Microwaves	TO	Klystron valve or magnetron valve.
Infrared waves	TO	Vibration of atoms and molecules
X-rays	TO	X-ray tubes or inner shell electrons.
Gamma rays	TO	Radioactive decay of the nucleus.

Intensity of EM waves

Linear momentum of EM waves with energy 'U' is given by,

$$P = \frac{U}{C}$$

Electromagnetic Waves

Electric and magnetic phenomena are not totally independent, but are related to each other. By the middle of the nineteenth century, several empirical laws of electricity and magnetism had been established. However, there was no convincing theoretical explanation for these phenomena. A comprehensive theory which could explain all the electric and magnetic phenomena was developed by James Clerk Maxwell around 1872. This theory is referred to as the 'electromagnetic theory'. Maxwell unified not only the apparently distinct theories on electricity and magnetism but also showed that light is electromagnetic in nature.

Maxwell's equations

1. $\oint \vec{E} \cdot d\vec{S} = \frac{q}{\epsilon_0}$: Gauss' law in electrostatics
2. $\oint \vec{B} \cdot d\vec{S} = 0$: Gauss's law in magnetism.
3. $\oint \vec{E} \cdot d\vec{l} = -\frac{dQ_B}{dt}$: Faraday's law of electromagnetic induction
4. $\oint \vec{E} \cdot d\vec{l} = \mu_0(I_c + I_d)$: Ampere-Maxwell law.

Displacement current

The term I_d in the fourth equation is called displacement current. $I_d = \epsilon_0 \frac{d\phi_E}{dt}$

Displacement current through a charging capacitor, $I_d = C \frac{dV}{dt}$

Electromagnetic waves

Electromagnetic waves consists of oscillating electric and magnetic fields. These fields oscillate in perpendicular directions,

perpendicular to the direction of propagation. In a plane electromagnetic wave, travelling along z direction the oscillations of the electric and magnetic fields are represented as

$$E_x = E_0 \sin(K_z - \omega t)$$

$$B_y = B_0 \sin(K_z - \omega t)$$

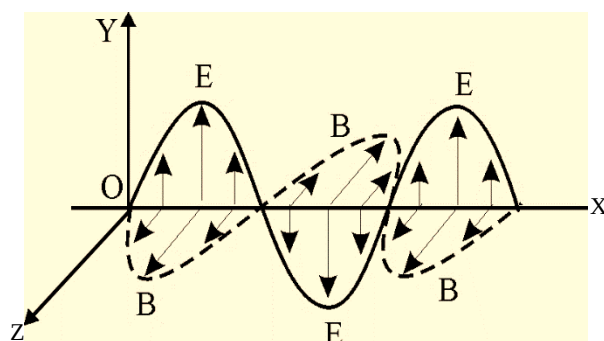
Here $k = \frac{2\pi}{\lambda}$; $\omega = 2\pi f$; $\frac{\omega}{K} = c$, the speed of propagation of the waves. It can be shown that $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$. Also $c = \frac{E_0}{B_0}$

(a) The intensity of electromagnetic wave is given by $I = \frac{1}{2} \epsilon_0 E_0^2 c = \frac{1}{2\mu_0} B_0^2 c$

(b) The average energy density of electromagnetic wave is given by $U_{av} = \frac{1}{2} \epsilon_0 E_0^2 = \frac{1}{2\mu_0} B_0^2$

(c) The momentum transferred by an electromagnetic wave on t an absorbing surface is given by $p = \frac{I}{c}$.

Properties of electromagnetic wave



Electromagnetic wave

1. Electromagnetic waves propagate in the form of time varying electric and magnetic fields such that the two fields are perpendicular to each other and also to the direction of propagation of the waves (Figure). In other words, electromagnetic waves are transverse in nature.
2. Electromagnetic waves are produced by accelerated charges
3. Electromagnetic waves travel in free space (or vacuum) with a speed c given by

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3 \times 10^8 \text{ ms}^{-1} \quad \dots (1)$$

μ_0 and ϵ_0 being the permeability and permittivity of free space which have values $4\pi \times 10^{-7} \text{ H m}^{-1}$ and $8.85 \times 10^{-12} \text{ F m}^{-1}$. The electromagnetic waves travel in a material medium of absolute permittivity ϵ and

absolute permeability μ with a speed v given by $v = \frac{1}{\sqrt{\mu\epsilon}} \quad \dots (2)$

4. Electromagnetic waves do not need any material medium for their propagation.
5. The ratio of the amplitudes of electric and magnetic fields is always a constant and it is equal to the velocity of electromagnetic waves.

Mathematically, $\frac{E_0}{B_0} = c \quad \dots (3)$

6. The energy of electromagnetic waves is equally divided between the electric and magnetic field vectors.
7. The direction of flow of electromagnetic wave is given by the direction of a vector, called Poynting's vector ($\vec{S}$). The magnitude of $\vec{S}$ gives the amount of energy flowing normally across unit area $\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0}$

Electromagnetic spectrum

The orderly distribution of electromagnetic waves (according to wavelength or frequency) in the form of distinct groups, having widely different properties, is called electromagnetic spectrum. The spectrum of electromagnetic radiation has a wide range of wavelengths from radio-waves at one end to γ -rays at the other end. The spectrum from about 400 nm to 700 nm which is sensitive to human eye is called the visible spectrum. The spectrum is divided into various regions depending on the effects produced by them. A sequence of regions in the decreasing order of wavelengths is; radio waves, microwaves, infrared rays, visible light, ultraviolet rays, X-rays and γ -rays.

Table below gives details about the frequency range, mode of production and use of different types of electromagnetic waves in the order of decreasing wavelength.

Electromagnetic spectrum

	Name	Frequency range (Hz)	Mode of production	Uses
1	Radio waves	3×10^4 to 3×10^9	By accelerated motion of charges in conducting wires	Radio and TV communication, cellular phones in the UHF band
2.	Micro waves	3×10^9 to 3×10^{11}	Klystrons tubes, Magnetron tubes	Radar systems, Microwave ovens
3.	Infrared waves	3×10^{11} to 4×10^{14}	Hot bodies and molecules	Infrared lamps for physical therapy, For weather forecasting, to study the molecular structure and to check purity of the chemical samples, IR photography
4.	Visible light	4×10^{14} to 8×10^{14}	Emitted or reflected from objects around us	Information about the world around us
5.	UV rays	8×10^{14} to 5×10^{17}	Spectral lamps and very hot bodies	Molecular structure studies through UV spectra, Burglar alarm, to preserve food stuff
6.	X-rays	5×10^{17} to 3×10^{21}	By bombarding a metal target by high energy electrons	In medical applications, surgery, Radio therapy, industry and scientific research
7.	γ -rays	Above 3×10^{18} to 5 up to 10^{23}	Nuclear reactions and Radioactive nuclei	Treatment of cancer and tumours, preservation of food, in nuclear reactions, structure of atomic nucleus

Illustrations

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.

Ans (C)

$$E \text{ (in eV)} = \frac{hc}{e\lambda} \approx \frac{1242}{\lambda(\text{nm})}$$

$$\lambda(\text{in nm}) = \frac{1242}{11} \approx 113 \text{ nm}$$

$$\Rightarrow \text{Frequency, } \nu = \frac{3 \times 10^8}{1.13 \times 10^{-7}} = 2.65 \times 10^{15} \text{ Hz}$$

This lies in ultraviolet region

2. A linearly polarized electromagnetic wave given as $E = E_0 \hat{i} \cos(kz - \omega t)$ 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) $E_r = -E_0 \hat{i} \cos(kz - \omega t)$ (B) $E_r = E_0 \hat{i} \cos(kz + \omega t)$
(C) $E_r = -E_0 \hat{i} \cos(kz + \omega t)$ (D) $E_r = E_0 \hat{i} \sin(kz - \omega t)$

Ans (B)

The material is optically inactive. Thus, there is no rotation of the plane of polarization.

Since angle of incidence = 0. Angle of reflection = 0

Thus, reflected wave will be along the normal, in opposite direction to that of the incident wave.

For the reflected wave, $z = -z$, $\hat{z} = -\hat{z}$

There will be a phase change of π , when the wave is reflected from a denser medium. But this does not change the type of wave.

Incident electromagnetic wave is $E = E_0 \hat{i} \cos(kz - \omega t)$

Reflected electromagnetic wave is $E_r = E_0 (-\hat{i}) \cos[(-kz - \omega t) + \pi] = E_0 \hat{i} \cos[(kz + \omega t)]$

3. Light with an energy flux of 20 W cm^{-2} falls on a non-reflecting surface at normal incidence. If the surface has an area of 30 cm^2 , the total momentum delivered (for complete absorption) during 30 min is

(A) $36 \times 10^{-5} \text{ kg m s}^{-1}$ (B) $36 \times 10^{-4} \text{ kg m s}^{-1}$ (C) $108 \times 10^4 \text{ kg s}^{-1}$ (D) $1.08 \times 10^7 \text{ kg m s}^{-1}$

Ans (B)

Energy flux = $\phi = 20 \text{ W cm}^{-2} = 20 \times 10^4 \text{ Wm}^{-2}$

Area, $A = 30 \text{ cm}^2 = 30 \times 10^{-4} \text{ m}^2$

Time, $t = 30 \text{ minutes} = 30 \times 60 \text{ s}$

Total energy falling on the surface in a time t is

$$U = \phi A t = 20 \times 10^4 \times 30 \times 10^{-4} \times 30 \times 60 = 1.08 \times 10^6 \text{ J}$$

Momentum of the incident light

$$= \frac{U}{c} = \frac{1.08 \times 10^6}{3 \times 10^8} = 36 \times 10^{-4} \text{ kg ms}^{-1}$$

Momentum of the reflected light = 0

$\therefore$ Momentum transferred to the surface

$$= 36 \times 10^{-4} - 0 = 36 \times 10^{-4} \text{ kg m s}^{-1}$$

4. The electric field intensity produced by the radiations coming from 100 W bulb at 3 m distance is E . The electric field intensity produced by the radiations coming from 50 W bulb at the same distance is

(A) $\frac{E}{2}$ (B) $2E$ (C) $\frac{E}{\sqrt{2}}$ (D) $\sqrt{2}E$

Ans (C)

$$I = \frac{P}{4\pi r^2} \text{ Also } I = c\epsilon_0 E^2$$

$$\therefore E^2 \propto P$$

$$\frac{E_2^2}{E_1^2} = \frac{P_2}{P_1} \Rightarrow \frac{50}{100} = \frac{1}{2} ;$$

$$E_2 = \frac{E_1}{\sqrt{2}}$$

5. If $\vec{E}$ and $\vec{B}$ represent electric and magnetic field vectors of the electromagnetic wave, the direction of propagation of electromagnetic wave is along.

(A) $\vec{E}$ (B) $\vec{B}$ (C) $\vec{B} \times \vec{E}$ (D) $\vec{E} \times \vec{B}$

Ans (D)

The direction of propagation of an EM wave is perpendicular to both electric field vector $\vec{E}$ and magnetic field vector $\vec{B}$. It is in the direction of $\vec{E} \times \vec{B}$.

6. 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) $\sqrt{c} : 1$

Ans (C)

Intensity of EM wave; $I = U_{av} c$. We have, $U_{av} = \frac{1}{2} \epsilon_0 E_0^2$

$$c = \frac{E_0}{B_0}, (U_{av})_{\text{elec. field}} = \frac{1}{2} \epsilon_0 (cB_0)^2 = \frac{1}{2} \epsilon_0 \left(\frac{1}{\mu_0 \epsilon_0} \right)$$

Since,

$$B_0^2 = \frac{1}{2} \frac{B_0^2}{\mu_0} \left(\because c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \right)$$

We know that $(U_{av})_{\text{mag. field}} = \frac{1}{2} \frac{B_0^2}{\mu_0}$

Thus, the energy in an electromagnetic wave is divided equally between electric field vector and magnetic field vector.

7. An EM wave radiates outwards 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.

Ans (C)

The electromagnetic waves are radiated outwards from a dipole antenna. The amplitude of electric field E_0 varies inversely as the distance from the antenna

$$\text{i.e. } E_0 \propto \frac{1}{r}.$$

8. A plane electromagnetic wave propagating along x-direction can have the following pairs of E and B

- (A) E_x, B_y (B) E_y, B_z (C) B_x, E_y (D) E_z, B_x

Ans (B)

In an electromagnetic wave $\vec{E}$ and $\vec{B}$ are perpendicular to each other and also perpendicular to the direction of propagation.

$\therefore$ In a electromagnetic wave propagating along x-direction, a possible pair is E_y, B_z .

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

- (A) will have frequency of 2×10^9 Hz. (B) will have speed of 30 ms^{-1}
(C) will have a wavelength of 0.3 m. (D) fall in the region of infrared waves.

Ans (C)

$$\nu = 10^9 \text{ Hz} \therefore \lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{10^9} = 0.3 \text{ m} ; \text{ lies in microwave region.}$$

10. 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) in an electric field

Ans (B)

An electromagnetic wave can be produced by an accelerated or an oscillating charge. In option (B), the charge will be in accelerated motion.

11. At every instant the ratio of the magnitude of the electric field to the magnetic field in an electromagnetic wave in vacuum is equal to

- (A) the speed of radiowaves (B) the speed of γ -rays
(C) the speed of light (D) all of the above

Ans (D)

$$c = \frac{E}{B} = \text{Speed of an electromagnetic wave in vacuum}$$

12. A parallel plate capacitor consists of two circular plates each of radius 10 cm and separated by 5 mm. By an external source the capacitor is being charged. The charging current is 0.1 A. The rate of change of potential difference between the plates is nearly
- (A) $3.6 \times 10^8 \text{ Vs}^{-1}$ (B) $3.6 \times 10^9 \text{ Vs}^{-1}$
 (C) $1.8 \times 10^8 \text{ Vs}^{-1}$ (D) $1.8 \times 10^9 \text{ Vs}^{-1}$

Ans (D)

$$Q = CV \therefore \frac{dQ}{dt} = C \frac{dV}{dt} \Rightarrow I = C \frac{dV}{dt}$$

$$\frac{dV}{dt} = \frac{I}{C} = \frac{I}{(\epsilon_0 A / d)} = \frac{Id}{\epsilon_0 A}$$

$$= \frac{0.1 \times 5 \times 10^{-3}}{8.85 \times 10^{-12} \times 3.14 \times (10 \times 10^{-2})^2} = 1.8 \times 10^9 \text{ Vs}^{-1}$$

13. The potential difference between the plates of a parallel plate capacitor of capacitance $5 \mu\text{F}$ varies at the rate of 300 kVs^{-1} . The displacement current between the plate is
- (A) 1 A (B) 0.6 A (C) 1.66 A (D) 1.5 A

Ans (D)

$$C = 5 \mu\text{F}, \frac{dV}{dt} = 300 \text{ kVs}^{-1} = 3 \times 10^5 \text{ Vs}^{-1}, Q = CV$$

$$I_d = \frac{dQ}{dt} = C \frac{dV}{dt} = 5 \times 10^{-6} \times 3 \times 10^5 = 1.5 \text{ A}$$

14. *The force exerted by sun light of intensity 1350 Wm^{-2} reflected from a reflecting surface of an aluminum sheet of area 10^4 m^2 is
- (A) 0.72 N (B) 0.09 N (C) 45 N (D) 0.18 N

Ans (B)

$$\text{Radiation pressure on reflecting surface is } P = \frac{2I}{c} = \frac{2 \times 1350}{3 \times 10^8} \text{ Nm}^{-2}$$

Total force on the surface = PA

$$= \frac{2 \times 1.35 \times 10^3}{3 \times 10^8} \times 10^4 = 9 \times 10^{-2} \text{ N}$$

15. The electromagnetic energy contained in cubic meter near the earth's surface is (given intensity of sunlight under clear sky is 10^3 W m^{-2})
- (A) $3.3 \times 10^{-6} \text{ J}$ (B) 3.3 J (C) $3 \times 10^{-3} \text{ J}$ (D) $3.0 \times 10^{-5} \text{ J}$

Ans (A)

Intensity = energy (E) contained in a cylinder of unit area of cross section and length equal to the distance travelled by light in vacuum in 1 second (i.e., volume $(1 \times c) \text{ m}^3$).

$$\text{Energy per unit volume} = \frac{\text{Intensity}}{\text{velocity of light}}$$

$$= \frac{1000}{3 \times 10^8} = \frac{1}{3} \times 10^{-5} = 3.3 \times 10^{-6} \text{ J}$$

16. The maximum radiation pressure exerted by sunlight outside earth's atmosphere on a black flat surface is (solar constant = 1350 Wm^{-2})
- (A) $2.25 \times 10^{-5} \text{ Pa}$ (B) 0.06 Pa (C) 0.09 Pa (D) $4.5 \times 10^{-6} \text{ Pa}$

Ans (D)

$$\text{Radiation pressure on the black surface is } P = \frac{I}{c} = \frac{1350}{3 \times 10^8} = 4.5 \times 10^{-6} \text{ Pa}$$

17. The magnetic field of a plane polarized electromagnetic wave moving along z-direction is given by

$B = 1.2 \times 10^{-6} \sin \left[2\pi \left(\frac{z}{240} - \frac{t \times 10^7}{8} \right) \right]$ tesla. The maximum electric field is

- (A) 1000 V m^{-1} (B) 180 V m^{-1} (C) 360 V m^{-1} (D) 0.40 V m^{-1}

Ans (C)

Electric field $E_{\max} = B_{\max} \times c = 1.2 \times 10^{-6} \times 3 \times 10^8 = 360 \text{ Vm}^{-1}$

- 18.** A solar cell has a light gathering area of 10 cm^2 and produces 0.2 A at 0.8 V (DC) when illuminated with sunlight of intensity 1000 Wm^{-2} . The efficiency of the solar cell is

- (A) 8% (B) 16% (C) 23% (D) 32%

Ans (B)

Power generated, $P = VI = 0.8 \times 0.2 = 0.16 \text{ W}$.

Power incident on the solar cell is $P_0 = 1000 \times 10 \times 10^{-4} = 1 \text{ W}$

$$\text{Efficiency} = \frac{P}{P_0} \times 100 = \frac{0.16}{1} \times 100 = 16\%$$

- 19.** The amplitude of electric field in an electromagnetic wave is 10 V m^{-1} . The frequency of wave is $5 \times 10^{14} \text{ Hz}$. The wave is propagating along z-axis. The average energy density of electric field is

- (A) $2.21 \times 10^{-10} \text{ J m}^{-3}$ (B) $4.21 \times 10^{-10} \text{ J m}^{-3}$
(C) $3.21 \times 10^{-10} \text{ J m}^{-3}$ (D) $1.21 \times 10^{-10} \text{ J m}^{-3}$

Ans (A)

Here, $E_0 = 10 \text{ Vm}^{-1}$

Average energy density due to electric field is

$$\begin{aligned} u_E &= \frac{1}{2} \epsilon_0 E_{\text{rms}}^2 = \frac{1}{2} \epsilon_0 \left(\frac{E_0}{\sqrt{2}} \right)^2 \\ &= \frac{1}{4} \epsilon_0 E_0^2 = \frac{1}{4} \times (8.85 \times 10^{-12}) \times (10)^2 \\ &= 2.21 \times 10^{-10} \text{ J m}^{-3} \end{aligned}$$

- 20.** The amplitude of electric field in an electromagnetic wave is 10 V m^{-1} . The frequency of wave is $5 \times 10^{14} \text{ Hz}$. The wave is propagating along z-axis. The average energy density of magnetic field is

- (A) $3.21 \times 10^{-10} \text{ J m}^{-3}$ (B) $2.21 \times 10^{-10} \text{ J m}^{-3}$
(C) $1.21 \times 10^{-10} \text{ J m}^{-3}$ (D) $4.21 \times 10^{-10} \text{ J m}^{-3}$

Ans (B)

Here, $E_0 = 10 \text{ V m}^{-1}$; $\nu = 5 \times 10^{14} \text{ Hz}$.

Average energy density of magnetic field is $u_B = \frac{1}{2} \frac{B_{\text{rms}}^2}{\mu_0} = \frac{1}{2\mu_0} \left(\frac{B_0}{\sqrt{2}} \right)^2$

$$\begin{aligned} \frac{1}{4} \frac{B_0^2}{\mu_0} &= \frac{1}{4} \frac{(E_0 / c)^2}{\mu_0} = \frac{1}{4\mu_0} \frac{E_0^2}{(1/\mu_0 \epsilon_0)} \\ &= \frac{1}{4} \epsilon_0 E_0^2 = u_E = 2.21 \times 10^{-10} \text{ J m}^{-3} \end{aligned}$$

Alternately, the average density is the same for electric and magnetic field.

Each of the following questions consists of a Statement-I and a Statement-II. Examine both of them and select one of the options using the following codes:

(A) Statement-I and Statement-II are true and Statement-II is the correct explanation of Statement-I.

(B) Statement-I and Statement-II are true, but Statement-II is not the correct explanation of Statement -I

(C) Statement-I is true, but Statement -II is false

(D) Statement-I is false, but Statement -II is true

21. **Statement I:** Gauss' law in magnetism, suggests that no magnetic monopole exists.

Statement II: Gauss' law in magnetism states that $\oint \vec{B} \cdot d\vec{A} = 0$.

Ans (A)

22. **Statement I:** Induced electric fields are produced by time varying magnetic field.

Statement II: According to Faraday's law $\oint \vec{E} \cdot d\vec{l} = -\frac{d\phi_B}{dt}$

Ans (A)

23. **Statement I:** When a capacitor is getting charged the conduction current in the connecting wires at any instant is equal to the displacement current in between the capacitor plates.

Statement II: Conduction current is always greater than the displacement current

Ans (C)

24. **Statement I:** Charges at rest or uniform motion generate electromagnetic waves.

Statement II: Accelerated charges radiate electromagnetic waves.

Ans (D)

25. **Statement I:** In an electromagnetic wave, the energy density of the electric field is equal to the energy density of the magnetic field.

Statement II: In an electromagnetic wave, the energy density of the electric field is greater than the energy density of the magnetic field.

Ans (C)

26. **Statement I:** The tails of comets are always oriented in a direction away from sun.

Statement II: Electromagnetic waves exert pressure.

Ans (A)

27. **Statement I:** In an electromagnetic wave traveling along x-direction the electric field vibrates along the y-direction and the magnetic field vibrates along the z-direction.

Statement II: In an electromagnetic wave traveling along x-direction the magnetic field vibrates along the y-direction and the electric field vibrates along the z-direction.

Ans (C)

28. **Statement I:** The radiation force on an absorbing surface is twice that on a reflecting surface.

Statement II: The radiation force on a reflecting surface is twice that on an absorbing surface.

Ans (D)

29. **Statement I:** A light beam or a radio beam of same intensity will have same values of $\vec{E}$ and $\vec{B}$

Statement II: A light beam or a radio beam of same intensity will have different values of $\vec{E}$ and $\vec{B}$

Ans (C)

30. **Statement I:** UV rays are used for sterilizing surgical instruments in hospitals.

Statement II: IR rays are used for sterilizing surgical instruments in hospitals

Ans (C)

NCERT LINE BY LINE QUESTIONS

1. The correct order of arrangement of electromagnetic waves according to their frequency is [NCERT Pg. 283]
 - (1) Radio waves > Microwaves > γ -rays > U.V. rays
 - (2) Radio waves > U.V. rays > Microwaves > γ -rays
 - (3) γ -rays > Microwaves > U.V. rays > Radio waves
 - (4) γ -rays > U.V. rays > Microwaves > Radio waves
2. The electromagnetic radiations used in radar system is [NCERT Pg. 281]
 - (1) Gamma rays
 - (2) Radio waves
 - (3) Infrared
 - (4) Microwaves
3. Microwaves oven works on the principle of [NCERT Pg.281]
 - (1) Giving rotational energy to water molecules
 - (2) Giving vibrational energy to water molecules
 - (3) Giving translational energy to water molecules
 - (4) Both (1) and (2) are correct options
4. The RMS value of electric field of light coming from sun is 400 N C^{-1} . Total energy density of electromagnetic waves is [NCERT Pg. 279]
 - (1) $1.42 \times 10^{-6} \text{ Jm}^{-3}$
 - (2) $1.92 \times 10^{-6} \text{ Jm}^{-3}$
 - (3) $2.6 \times 10^{-5} \text{ Jm}^{-3}$
 - (4) $8.85 \times 10^{-7} \text{ Jm}^{-3}$
5. Cellular phones use radio waves to transmit voice communication in [NCERT Pg. 281]
 - (1) Frequency modulated radio bands
 - (2) Ultra high frequency bands
 - (3) Short wave bands
 - (4) Amplitude modulated bands
6. Which of the following is not an electromagnetic wave? [NCERT Pg. 283]
 - (1) Heat rays
 - (2) X-rays
 - (3) α -rays
 - (4) β -rays
7. Which among the following statement is incorrect? (NCERT Pg. 283)
 - (1) Wavelength of X-rays can range from 10 nm to 10^{-4} nm .
 - (2) X-rays are used in treatment of certain form of cancer
 - (3) X-rays are produced by bombarding a metal target by high energy electrons
 - (4) X-rays are used to observe growth of crops
8. Which among the following statement may be incorrect? [NCERT Pg. 282]
 - (1) Infrared detectors are used in earth satellites
 - (2) Electronic devices emit infrared radiations and are used in remote switches
 - (3) U.V. lamps are used in physical therapy
 - (4) Visible range of many insects extend well into ultraviolet waves
9. The instantaneous magnitudes of electric field E and magnetic field B vectors in electromagnetic wave propagating in vacuum are related as [NCERT Pg. 276]
 - 1) $E = \frac{c}{B}$
 - 2) $E = cB$
 - 3) $E = \frac{B}{c}$
 - 4) $EB = c^2$
10. A plane electromagnetic wave $E = 100 \sin(5 \times 10^8 t + 3x) \text{ V/m}$ is propagating through a medium. The refractive index of the medium is [NCERT Pg.276]

- (1) 1.6 (2) 1.7 (3) 1.8 (4) 1.9
11. Light with energy flux 1.2 W/m^2 falls on a non-reflecting surface at normal incidence. The pressure on the plate is [NCERT Pg.279]
 (1) $3 \times 10^{-8} \text{ Nm}^{-2}$ (2) $2 \times 10^{-8} \text{ Nm}^{-2}$ (3) $4 \times 10^{-9} \text{ Nm}^{-2}$ (4) $2 \times 10^{-9} \text{ Nm}^{-2}$
12. What is peak electric field produced by the radiations coming from 100 W bulb at a distance 3 m. Assuming that bulb is point source with efficiency of 2.5%? [NCERT Pg. 279]
 (1) 2.9 V/m (2) 3.1 V/m (3) 1.6 V/m (4) 4.07 V/m
13. In electromagnetic wave, if peak value of magnetic field is $1.4 \times 10^{-8} \text{ T}$, then RMS value of electric field will be [NCERT Pg. 280]
 (1) 4.07 V/m (2) 2.9 V/m (3) 6.2 V/m (4) 3.4 V/m
14. Light with an energy flux of 6 W/cm^2 falls on a non reflecting surface at normal incidence. If surface has an area of 50 cm^2 . What is total momentum transferred in one minute to the surface (for complete absorption)? [NCERT Pg. 279]
 (1) $6 \times 10^{-5} \text{ kg m s}^{-1}$ (2) $3 \times 10^{-5} \text{ kg m s}^{-1}$
 (3) $2 \times 10^{-5} \text{ kg m s}^{-1}$ (4) 6.4 kg m s^{-1}
15. The electric field component propagating along x-axis is given as $E_y = 30 \sin(4.5 \times 10^2 x + 1.5 \times 10^{11} t) \text{ V/m}$. The frequency of propagating wave is [NCERT Pg. 278]
 (1) 5 GHz (2) 17.6 GHz (3) 23.9 GHz (4) 15.4 GHz
16. A capacitor is made of two circular plates each of radius 7 cm and separated by 2 cm. The capacitor is being charged by an external source. The charging current is constant and equal to 0.2 A. What is the rate of change of potential difference between the plates? [NCERT Pg.285]
 (1) $1.62 \times 10^{10} \text{ V/S}$ (2) $2.94 \times 10^{10} \text{ V/S}$ (3) $3.54 \times 10^{10} \text{ V/s}$ (4) $3.24 \times 10^{10} \text{ V/S}$
17. A radio is tuned to station in the 30 MHz to 54 MHz. What is corresponding wavelength band? [NCERT Pg.281]
 (1) AM band (2) FM band (3) Short band (4) UHF band
18. Which among the following statement is incorrect in electromagnetic spectrum? [NCERT Pg. 282]
 (1) Long distance radio broadcast use short waves
 (2) X-rays astronomy is possible from satellite orbiting earth
 (3) Microwaves range from 400 nm to 0.6 nm
 (4) Snakes are sensitive to infrared waves
19. Correct match of column I with column II is [NCERT Pg. 283]
C-I(waves) **C-II (Production)**
 A. Infra-red P . Rapid vibration of electrons in aerials
 B. Radio Q . Electrons in atoms emit light when they move from higher to lower energy level.
 C. Light R . Klystron valve
 D. Microwave S . Vibration of atoms and molecules
 (1) A-P, B-R, C-S, D-Q (2) A-S, B-P, C-O, D-R
 (3) A-Q, B-P, C-S, D-R (4) A-S, B-R, C-P, D-Q
20. Find the incorrect statement among the following. [NCERT Pg. 285]
 (1) Accelerated charge particles radiate electromagnetic waves
 (2) Visible radiations emitted by atoms is much longer in wavelength than atomic size

- (3) X-rays are emitted from heavy atoms
 (4) Radio waves are produced by atomic nucleus

NCERT BASED PRACTICE QUESTIONS

- 1 Accelerated charge radiate
 (a) Electric field (b) Magnetic field
 (c) Electromagnetic waves (d) None of these
- 2 In above question the frequency of the wave
 (a) 23.9 GHz (b) 2.39 GHz (c) 239 GHz (d) None of these
3. The wavelength of visible light in electromagnetic waves
 (a) 300 – 400 nm (b) 200 – 300 nm
 (c) 700 – 400 nm (d) None of these
4. Snake can detect
 (a) Infrared waves (b) Ultraviolet waves
 (c) Microwaves (d) Radio waves
5. Visible range of insects
 (a) Infrared waves (b) Ultra violet waves
 (c) Gamma waves (d) None of these
6. The air pressure with height
 (a) Increases (b) Decreases (c) Both (a) & (b) (d) None of these
7. 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?
 (a) 10^9 Hz (b) 10^{12} Hz (c) 10^8 Hz (d) None of these
8. The medium wave frequency (MF)
 (a) $300 \text{ kHz} - 3 \text{ MHz}$ (b) $3 \text{ MHz} - 30 \text{ MHz}$
 (c) $30 \text{ MHz} - 3 \text{ GHz}$ (d) None of these
9. The high frequency waves
 (a) $300 \text{ kHz} - 3 \text{ MHz}$ (b) $3 \text{ MHz} - 30 \text{ MHz}$
 (c) $30 \text{ MHz} - 3 \text{ GHz}$ (d) None of these
- 10 A plane electromagnetic wave of frequency 25 MHz travels in free space along the x-direction. At a particular point in space and time. $E = 6.3 \hat{j} \text{ V/m}$. What is B at this point?
 (a) $2.1 \times 10^{-5} \hat{k} \text{ T}$ (b) $2.1 \times 10^{-9} \hat{k} \text{ T}$ (c) $2.1 \times 10^{-8} \text{ T}$ (d) None of these
11. The magnetic field in a plane electromagnetic wave is given by $B_y = 2 \times 10^{-7} \sin (0.5 \times 10^3 x + 1.5 \times 10^{11} t) \text{ T}$. What is the wavelength of the wave?
 (a) 1.26 cm (b) 126 cm (c) 12.6 m (d) None

12. Light with an energy flux of 18 Watts/cm^2 falls on a non-reflecting surface at normal incidence. If the surface has an area of 20 cm^2 , find the average force exerted on the surface during a 30 minute time span.
 (a) $12 \times 10^{-5} \text{ N}$ (b) $1.2 \times 10^{-6} \text{ N}$ (c) $12 \times 10^{-7} \text{ N}$ (d) None
13. Calculate the rms value of electric field and magnetic field produced by the radiation coming from a 100 W bulb at a distance of 3 m. Assume that the efficiency of the bulb is 2.5% and it is a point source.
 (a) 2.9 V/m (b) 29 V/m (c) 29 (d) $2.9 \times 10^{-2} \text{ V/m}$
14. Fig. shows a capacitor made of two circular plates each of radius 12 cm, and separated by 5.0cm. The capacitor is being charged by an external source (not shown in the fig.). The charging current is constant and equal to 0.15A. Calculate the capacitance and the rate of change of potential difference between the plates.
 (a) $187 \times 10^9 \text{ V s}^{-1}$ (b) $.187 \times 10^9 \text{ Vs}^{-1}$
 (c) $1.87 \times 10^9 \text{ V s}^{-1}$ (d) $1.8 \times 10^8 \text{ Vs}^{-1}$
15. A parallel plate capacitor (Fig) made of circular plates each of radius $R = 6.0 \text{ cm}$ has capacitance $C = 100 \text{ pF}$. The capacitor is connected to a 230 v ac supply with a (angular) frequency of 300 rad s^{-1} .
 What is the rms value of the conduction current?
 (a) 6.9A (b) 79A (c) 89A (d) 7.9A
16. A plane electromagnetic wave travels in vacuum along z-direction. If the frequency of the wave is 30 MHz, what is its wavelength?
 (a) 20 m (b) 50 m (c) 10 m (d) 40 m
17. A radio can tune in to any station in the 7.5 MHz to 12 MHz band. What is the corresponding wavelength band?
 (a) 50m - 25 m (b) 40 m- 25 m (c) 55 m – 60 m (d) 60 m- 70 m
18. 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?
 (a) 10^6 Hz (b) 10^5 Hz (c) 10^9 Hz (d) None
19. The amplitude of the magnetic field part of a harmonic electromagnetic wave in vacuum is $B = 510 \text{ nT}$. What is the amplitude of the electric field part of the wave?
 (a) 153 N/C (b) 163 N/C (c) 173 N/C (d) 143 N/C
20. Suppose that the electric field amplitude of an electromagnetic wave is $E_0 = 120 \text{ N/C}$ and that its frequency is $\nu = 50.0 \text{ MHz}$. Determine, B_0 , λ , k , and ω .
 (a) 40 nT, $3.1 \times 10^8 \text{ rad /s}$, 1.5 rad/m , 6.00 m.
 (b) 600 nT, $3.4 \times 10^8 \text{ rad /s}$, 105 rad/m , 6.00 m.
 (c) 400 nT, $3.14 \times 10^8 \text{ rad /s}$, 1.05 rad/m , 6.00 m.
 (d) None
21. In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of $2.0 \times 10^{10} \text{ Hz}$ and amplitude 48 V m^{-1} . What is the wavelength of the wave?

- (a) $2.5 \times 10^{-2} \text{ m}$ (b) $1.5 \times 10^{-2} \text{ m}$ (c) $3.5 \times 10^{-2} \text{ m}$ (d) None
22. Suppose that the electric field part of an electromagnetic wave in vacuum is $E = \{3.1 \text{ N/C}\} \cos [(1.8 \text{ rad/m}) y + 5.4 \times 10^6 \text{ rad/s} t]$. What is the direction of propagation?
- (a) $\hat{j}$ (b) $\hat{k}$ (c) $-\hat{k}$ (d) None
23. About 5% of the power of a 100 W light bulb is converted to a visible radiation. What is the average intensity of visible radiation at a distance of 1 m from the bulb? Assume that the radiation is emitted isotropically and neglect reflection?
- (a) 4 W/m^2 (b) 4.5 W/m^2 (c) 0.4 W/m^2 (d) 3 W/m^2
24. If $\vec{E}$ and $\vec{B}$ represent electric and magnetic field vectors of the electromagnetic waves, then the direction of propagation of the electromagnetic waves is that of
- (a) $\vec{E}$ (b) $\vec{B}$ (c) $\vec{E} \times \vec{B}$ (d) None of these
25. Which of the following rays are not electromagnetic waves?
- (a) γ -rays (b) β -rays (c) X-rays (d) heat rays.
26. Which of the following has minimum wavelength?
- (a) X-rays (b) Ultraviolet rays (c) γ -rays (d) Cosmic rays
27. According to Maxwell's hypothesis, a changing electric field give rise to
- (a) an e.m.f (b) electric current
(c) magnetic field (d) pressure gradient
28. Velocity of light is equal to
- (a) $\sqrt{\epsilon_0 \mu_0}$ (b) ϵ_0 / μ_0 (c) $\sqrt{\epsilon_0 / \mu_0}$ (d) $\sqrt{\frac{1}{\epsilon_0 \mu_0}}$
29. If the frequency of EM radiations is halved then the energy of EM radiation will become
- (a) double (b) remains unchanged
(c) becomes half (d) becomes one fourth
30. Select the wrong statement. EM waves
- (a) are transverse in nature.
(b) travel in free space at a speed of light.
(c) are produced by accelerating charges.
(d) travel in all media with same speed.
31. Which of the following has/have zero average value in a plane electromagnetic wave?
- (a) Both magnetic and electric field (b) Electric field only
(c) Magnetic energy (d) Electric energy
32. The electromagnetic waves
- (a) travel with the speed of sound
(b) travel with the same speed in all media
(c) travel in free space with the speed of light
(d) do not travel through a medium
33. Displacement current is
- (a) continuous when electric field is changing in the circuit
(b) continuous when magnetic field is changing in the circuit
(c) continuous in both types of fields
(d) continuous through wires and resistance only

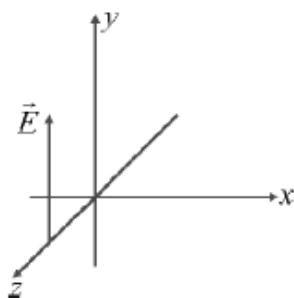
34. When an electromagnetic waves enter the ionised layer of ionosphere, the motion of electron cloud produces a space current and the electric field has its own capacitative displacement current, then
 (a) the space current is in phase of displacement current
 (b) the space current lags behind the displacement current by a phase 180° .
 (c) the space current lags behind the displacement current by a phase 90° .
 (d) the space current leads the displacement current by a phase 90° .
35. Radio waves and visible light in vacuum have
 (a) same velocity but different wavelength
 (b) same frequency
 (c) different velocity
 (d) same wavelength
36. Assertion : The velocity of electromagnetic waves depends on electric and magnetic properties of the medium.
 Reason : Velocity of electromagnetic waves in free space is constant.
 (a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
 (b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
 (c) Assertion is correct, reason is incorrect
 (d) Assertion is incorrect, reason is correct.
37. The magnetic field in a travelling electromagnetic wave has a peak value of 20 nT. The peak value of electric field strength is
 (a) 3 V/m (b) 6 V/m (c) 9 V/m (d) 12 V/m
38. When an electromagnetic wave enters an ionised layer of earth's atmosphere present in ionosphere
 (a) the electron cloud will not oscillate in the electric field of the wave
 (b) the electron cloud will oscillate in the electric field of wave in the phase of sinusoidal electromagnetic wave
 (c) the electron cloud will oscillate in the electric field of wave in the opposite phase of sinusoidal electromagnetic wave
 (d) the electron cloud will oscillate in the electric field of wave with a phase retardation of 90° for a sinusoidal electromagnetic wave.
39. The ozone layer converts the ultraviolet radiation to [which is used to heat the atmosphere and the earth's surface.]
 (a) Infrared (b) Visible ray (c) g-ray (d) None of these
40. The amplitude of an electromagnetic wave in vacuum is doubled with no other changes made to the wave. As a result of this doubling of the amplitude, which of the following statements are incorrect?
 I. The speed of wave propagation chages only
 II. The frequency of the wave changes only
 III. The wavelength of the wave changes only
 (a) I and II (b) II and III (c) I and III (d) I, II and III

41. We consider the radiation emitted by the human body. Which one of the following statements is true?
 (a) The radiation emitted is in the infrared region.
 (b) The radiation is emitted only during the day.
 (c) The radiation is emitted during the summers and absorbed during winters.
 (d) The radiation is emitted lies in the ultraviolet region and hence is not visible.
42. Which of the following electromagnetic waves has the longest wavelength?
 (a) uv-rays (b) Visible light (c) Radio waves (d) Microwaves
43. Which of the following is of shortest wavelength?
 (a) X-rays (b) γ -rays (c) Microwaves (d) Radio waves
44. Which of the following is the infrared wavelength?
 (a) 10^{-4} cm (b) 10^{-5} cm (c) 10^{-6} cm (d) 10^{-7} cm
45. The wavelength of X-ray is of the order of
 (a) 1 metre (b) 1 cm (c) 1 micron (d) 1 angstrom
46. Radio waves do not penetrate in the band of
 (a) ionosphere (b) mesosphere (c) troposphere (d) stratosphere
47. What is the cause of "Green house effect"?
 (a) Infrared rays (b) Ultraviolet rays (c) X-rays (d) Radio waves
48. **Assertion** : The basic difference between various types of electromagnetic waves lies in their wavelength or frequencies.
Reason : Electromagnetic waves travel through vacuum with the same speed.
 (a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
 (b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
 (c) Assertion is correct, reason is incorrect
 (d) Assertion is incorrect, reason is correct.
49. **Assertion** : Infrared radiation plays an important role in maintaining the average temperature of earth.
Reason : Infrared radiations are sometimes referred to as heat waves.
 (a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
 (b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
 (c) Assertion is correct, reason is incorrect
 (d) Assertion is incorrect, reason is correct.
50. It is possible to take pictures of those objects which are not fully visible to the eye using camera films sensitive to
 (a) ultraviolet rays (b) infrared rays (c) microwaves (d) radio waves
51. Which of the following wave can not be produced by charges accelerating in AC circuits having an inductor and capacitor?
 (a) Radio wave (b) Microwave (c) Infrared (d) None of these

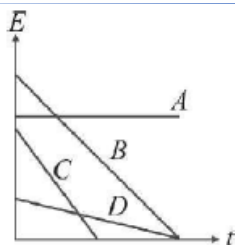
TOPIC WISE PRACTICE QUESTIONS

Topic 1: Electromagnetic Waves and Displacement Current

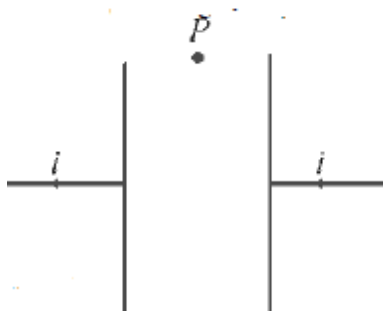
1. An electric charge oscillating with a frequency of 1 kilo cycles/second can radiate electro-magnetic waves of wavelength
 (1) 100 km (2) 200 km (3) 300 km (4) 400 km
2. Displacement current goes through the gap between the plates of a capacitor when the charge of the capacitor
 (1) increases (2) decreases (3) is zero (4) remains unchanged
3. The speed of electromagnetic wave is same for
 (1) odd frequencies (2) even frequencies (3) all frequencies (4) all intensities
4. The electromagnetic waves
 (1) travel with the speed of sound
 (2) travel with the same speed in all media
 (3) travel in free space with the speed of light
 (4) do not travel through a medium
5. The figure here gives the electric field of an electromagnetic wave at a certain point and a certain instant. The wave is transporting energy in the negative z-direction. The direction of the magnetic field of the wave at that point and instant is



- (1) + ve x-direction (2) -ve x-direction
 - (3) +ve z-direction (4) -ve y-direction
6. Displacement current flows
 (1) in between capacitor plates and wires of circuit
 (2) in between capacitor plates only
 (3) in resistance only
 (4) depends on emf of cell and value of R
7. If $\vec{E}$ and $\vec{B}$ are the electric and magnetic field vectors of e.m. waves then the direction of propagation of e.m. wave is along the direction of
 (1) $\vec{E}$ (2) $\vec{B}$ (3) $\vec{E} \times \vec{B}$ (4) None of these
8. The figure shows graphs of the electric field magnitude E versus time t for four uniform electric fields, all contained within identical circular regions. Which of them is according to the magnitudes of the magnetic field?



- (1) A (2) B (3) C (4) D
9. An electromagnetic wave of intensity I falls on a surface kept in vacuum and exerts radiation pressure P on it. Which of the following statements are true?
 I. Radiation pressure is I/c if the wave is totally absorbed.
 II. Radiation pressure is I/c if the wave is totally reflected.
 III. Radiation pressure is $2I/c$ if the wave is totally reflected.
 (1) I and II (2) I and III (3) III only (4) I, II and III
10. If a source is transmitting electromagnetic wave of frequency 8.2×10^6 Hz, then wavelength of the electromagnetic waves transmitted from the source will be
 (1) 36.6 m (2) 40.5 m (3) 42.3 m (4) 50.9 m
11. Figure shows a parallel plate capacitor and the current in the connecting wires that is discharging the capacitor.



- (1) The displacement current is leftward.
 (2) The displacement current is rightward
 (3) The electric field E is rightward
 (4) The magnetic field at point P is out the page.
12. A plane electromagnetic wave is incident on a material surface. If the wave delivers momentum p and energy E , then
 (1) $p = 0, E = 0$ (2) $p \neq 0, E \neq 0$ (3) $p \neq 0, E = 0$ (4) $p = 0, E \neq 0$
13. The electromagnetic waves do not transport
 (1) energy (2) charge (3) momentum (4) information
14. In electromagnetic wave, the average energy density is associated
 (1) with electric field only (2) with magnetic field only
 (3) equally with electric and magnetic fields (4) None of these
15. An electromagnetic wave passes through space and its equation is given by $E = E_0 \sin(\omega t - kx)$ where E is electric field. Energy density of electromagnetic wave in space is
 (1) $\frac{1}{2} \epsilon_0 E_0^2$ (2) $\frac{1}{4} \epsilon_0 E_0^2$ (3) $\epsilon_0 E_0^2$ (4) $2\epsilon_0 E_0^2$
16. A plane electromagnetic wave is incident on a plane surface of area A , normally and is perfectly reflected. If energy E strikes the surface in time t then average pressure exerted on the surface is (c = speed of light)
 (1) zero (2) E/Atc (3) $2E/Atc$ (4) E/c
17. The speed of electromagnetic wave in vacuum depends upon the source of radiation. It

- (1) increases as we move from g-rays to radio waves
 (2) decreases as we move from g-rays to radio waves
 (3) is same for all of them
 (4) None of these
18. Electromagnetic waves are transverse in nature is evident by
 (1) polarization (2) interference (3) reflection (4) diffraction
19. The magnetic field in a travelling electromagnetic wave has a peak value of 20 nT. The peak value of electric field strength is :
 (1) 3 V/m (2) 6 V/m (3) 9 V/m (4) 12 V/m
20. The electric field component of a monochromatic radiation is given by $\vec{E} = 2E_0 \hat{i} \cos kz \cos \omega t$.
 Its magnetic field $\vec{B}$ is then given by:
 (1) $\frac{2E_0}{c} \hat{j} \sin kz \cos \omega t$ (2) $\frac{2E_0}{c} \hat{j} \sin kz \sin \omega t$ (3) $\frac{E_0}{c} \hat{j} \sin kz \sin \omega t$ (4) $\frac{2E_0}{c} \hat{j} \cos kz \cos \omega t$
21. If c is the speed of electromagnetic waves in vacuum, its speed in a medium of dielectric constant K and relative permeability μ_r is
 (1) $v = \frac{1}{\sqrt{\mu_r K}}$ (2) $v = c\sqrt{\mu_r K}$ (3) $v = \frac{c}{\sqrt{\mu_r K}}$ (4) $v = \frac{K}{\sqrt{\mu_r C}}$
22. Which of the following type of radiations are radiated by an oscillating electric charge?
 (1) Electric (2) Magnetic (3) Thermoelectric (4) Electromagnetic
23. According to Maxwell's hypothesis, a changing electric field gives rise to
 (1) an e.m.f
 (2) electric displacement current
 (3) magnetic field
 (4) pressure gradient
24. For plane electromagnetic waves propagating in the z -direction, which one of the following combination gives the correct possible direction for $\vec{E}$ and $\vec{B}$ field respectively?
 (1) $(2\hat{i} + 3\hat{j})$ and $(\hat{i} + 2\hat{j})$ (2) $(-2\hat{i} - 3\hat{j})$ and $(3\hat{i} - 2\hat{j})$
 (3) $(3\hat{i} + 4\hat{j})$ and $(4\hat{i} - 3\hat{j})$ (4) $(\hat{i} + 2\hat{j})$ and $(2\hat{i} - \hat{j})$
25. A beam has intensity $2.5 \times 10^{14} \text{ Wm}^{-2}$. The ratio of electric and magnetic fields in the beam is
 (1) $2.98 \times 10^8 \text{ NC}^{-1}\text{T}^{-1}$ (2) $8.32 \times 10^5 \text{ NCT}^{-1}$ (3) $6.22 \times 10^7 \text{ NC}^{-1}\text{T}^{-1}$ (4) $2.88 \times 10^6 \text{ NCT}^{-1}$
26. Conduction current flows
 (1) only through resistance (2) through wires and resistance
 (3) only through capacitor (4) through wires, resistance and capacitor
27. The displacement current is
 (1) $\epsilon_0 d\phi_E / dt$ (2) $\frac{\epsilon_0}{R} d\phi_E / dt$ (3) $\epsilon_0 E / R$ (4) $\epsilon_0 q C / R$
28. If a source is transmitting electromagnetic wave of frequency $5.2 \times 10^6 \text{ Hz}$, then wavelength of the electromagnetic waves transmitted from the source will be
 (1) 57.6 m (2) 39.8 m (3) 94.8 m (4) 48.6 m
29. In an apparatus, the electric field was found to oscillate with an amplitude of 18 V/m. The magnitude of the oscillating magnetic field will be
 (1) $4 \times 10^{-6} \text{ T}$ (2) $6 \times 10^{-8} \text{ T}$ (3) $9 \times 10^{-9} \text{ T}$ (4) $11 \times 10^{-11} \text{ T}$

30. In an electromagnetic wave, the electric and magnetic fields are 100 V m^{-1} and 0.265 A m^{-1} . The maximum energy flow is
 (1) 26.5 W/m^2 (2) 36.5 W/m^2 (3) 46.7 W/m^2 (4) 765 W/m^2
31. A plane electromagnetic wave travels in free space along x-axis. At a particular point in space, the electric field along y-axis is 9.3 V m^{-1} . The magnetic induction (2) along z-axis is
 (1) $3.1 \times 10^{-8} \text{ T}$ (2) $3 \times 10^{-5} \text{ T}$ (3) $3 \times 10^{-6} \text{ T}$ (4) $9.3 \times 10^{-6} \text{ T}$
32. A new system of unit is evolved in which the values of μ_0 and ϵ_0 are 2 and 8 respectively. Then the speed of light in this system will be
 (1) 0.25 (2) 0.5 (3) 0.75 (4) 1
33. The average electric field of electromagnetic waves in certain region of free space is $9 \times 10^{-4} \text{ NC}^{-1}$. Then the average magnetic field in the same region is of the order of
 (1) $27 \times 10^{-4} \text{ T}$ (2) $3 \times 10^{-12} \text{ T}$ (3) $\left(\frac{1}{3}\right) \times 10^{-12} \text{ T}$ (4) $3 \times 10^{12} \text{ T}$
34. The amplitudes of electric and magnetic fields increases by a factor of 2 each then velocity of light:
 (1) decreases (2) remains constant (3) increases thrice (4) increases twice
35. The rms value of the electric field of the light coming from the Sun is 720 N/C . The average total energy density of the electromagnetic wave is
 (1) $4.58 \times 10^{-6} \text{ J/m}^3$ (2) $6.37 \times 10^{-9} \text{ J/m}^3$ (3) $81.35 \times 10^{-12} \text{ J/m}^3$ (4) $3.3 \times 10^{-3} \text{ J/m}^3$
36. In order to establish an instantaneous displacement current of 1 mA in the space between the plates of $2 \mu\text{F}$ parallel plate capacitor, the potential difference need to apply is
 (1) 100 Vs^{-1} (2) 200 Vs^{-1} (3) 300 Vs^{-1} (4) 500 Vs^{-1}
37. A plane electromagnetic wave travels in free space along X-direction. If the value of $\vec{B}$ (in tesla) at a particular point in space and time is $1.2 \times 10^{-8} \hat{k}$. The value of $\vec{E}$ (in Vm^{-1}) at that point is
 (1) $1.2 \hat{j}$ (2) $3.6 \hat{k}$ (3) $1.2 \hat{k}$ (4) $3.6 \hat{j}$
38. A plane electromagnetic wave propagating in the X-direction has wavelength of 3.0 mm . The electric field is in the Y-direction and its maximum magnitude is 10 Vm^{-1} . The equation for the electric field as a function of x and t is
 (1) $10 \sin \pi \left(t - \frac{x}{c} \right)$
 (2) $10 \sin \left[2\pi \times 10^{11} \left(t - \frac{x}{c} \right) \right]$
 (3) $10 \sin \pi \left(t - \frac{x}{c} \right)$
 (4) $10 \sin \left[\pi \times 10^{11} \left(t - \frac{x}{c} \right) \right]$

Topic 2: Electromagnetic Spectrum

39. The range of wavelength of visible light is
 (1) $10 \text{ \AA}$ to $100 \text{ \AA}$
 (2) $4000 \text{ \AA}$ to $8000 \text{ \AA}$
 (3) $8000 \text{ \AA}$ to $10,000 \text{ \AA}$
 (4) $10,000 \text{ \AA}$ to $15,000 \text{ \AA}$

40. Which of the following are not electromagnetic waves?
 (1) Cosmic rays (2) Gamma rays (3) β -rays (4) X-rays
41. The electromagnetic radiation used in food processing sterilizing agent is
 (1) microwaves (2) UV rays (3) gamma rays (4) radio waves
42. Microwaves are detected by
 (1) balometer (2) point contact diodes
 (3) thermopiles (4) the eye
43. Electromagnetic radiation of highest frequency is
 (1) infrared radiations (2) visible radiation (3) radio waves (4) γ -rays
44. Which of the following shows green-house effect?
 (1) Ultraviolet rays (2) Infrared rays (3) X-rays (4) None of these
45. Light of an electromagnetic radiation has an energy 2.06 eV each. To which region of electromagnetic spectrum does it belong ?
 (1) X-ray region (2) Ultra violet region
 (3) Infrared region (4) Visible region
46. Which rays are not the portion of electromagnetic spectrum?
 (1) X-rays (2) Microwaves (3) α -rays (4) Radio waves
47. The structure of solids is investigated by using
 (1) cosmic rays (2) X-rays (3) γ -rays (4) infra-red radiations
48. We consider the radiation emitted by the human body. Which of the following statements is true?
 (1) the radiation emitted lies in the ultraviolet region and hence is not visible.
 (2) the radiation emitted is in the infra-red region.
 (3) the radiation is emitted only during the day.
 (4) the radiation is emitted during the summers and absorbed during the winters.
49. Photons of an electromagnetic radiation has an energy 11 keV each. To which region of electromagnetic spectrum does it belong ?
 (1) X-ray region (2) Ultra violet region (3) Infrared region (4) Visible region
50. If v_s , v_x and v_m are the speed of soft gamma rays, X-rays and microwaves respectively in vacuum, then
 (1) $v_s > v_x > v_m$ (2) $v_s < v_x < v_m$ (3) $v_s > v_x < v_m$ (4) $v_s = v_x = v_m$
51. It is possible to take pictures of those objects which are not fully visible to the eye using camera films sensitive to
 (1) ultraviolet rays (2) infrared rays (3) microwaves (4) radio waves
52. The basic source of electromagnetic radiation is an accelerated :
 (1) charge (2) magnet (3) light (4) α -particle
53. The ozone layer converts the ultraviolet radiation to [which is used to heat the atmosphere and the earth's surface.]
 (1) Infrared ray (2) Visible ray (3) g-ray (4) None of these
54. Radio waves and visible light in vacuum have
 (1) same velocity but different wavelength
 (2) continuous emission spectrum
 (3) band absorption spectrum
 (4) line emission spectrum
55. Which of the following waves have the maximum wavelength?
 (1) X-rays (2) I.R. rays (3) UV rays (4) Radio waves
56. The ozone layer absorbs radiation of wavelengths
 (1) less than 3×10^{-7} m (2) more than 3×10^{-7} m

- (3) less than 3×10^{-5} m (4) more than 3×10^{-5} m
57. Radio waves with frequencies higher than television signals are
(1) ultrasonic waves (2) sound waves (3) light waves (4) microwaves
58. Which of the following electromagnetic waves has the longest wavelength?
(1) Heat waves (2) Visible light
(3) Radio frequency waves (4) Microwaves
59. Radio waves do not penetrate in the band of
(1) ionosphere (2) mesosphere (3) troposphere (4) stratosphere
60. A radar sends the waves towards a distant object and receives the signal reflected by object. These waves are
(1) sound waves (2) light waves (3) radio waves (4) microwaves

NEET PREVIOUS YEARS QUESTIONS

1. An em wave is propagating in a medium with a velocity $\vec{V} = V\hat{i}$. 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
[2018]
(1) -z direction (2) +z direction (3) -x direction (4) -y direction
2. In an electromagnetic wave in free space the root mean square value of the electric field is $E_{\text{rms}} = 6\text{V/m}$. The peak value of the magnetic field is :-
[2017]
(1) 2.83×10^{-8} T (2) 0.70×10^{-8} T (3) 4.23×10^{-8} T (4) 1.41×10^{-8} T
3. Out of the following options which one can be used to produce a propagating electromagnetic wave ?
[2016]
(1) A charge moving at constant velocity (2) A stationary charge
(3) A chargeless particle (4) An accelerating charge
4. A radiation of energy 'E' falls normally on a perfectly reflecting surface. The momentum transferred to the surface is (C = Velocity of light)
[2015]
(1) $\frac{2E}{C}$ (2) $\frac{2E}{C^2}$ (3) $\frac{E}{C^2}$ (4) $\frac{E}{C}$
5. The energy of the em waves is of the order of 15 keV. To which part of the spectrum does it belong?
[2015]
(1) Infra-red rays (2) Ultraviolet rays (3) g-rays (4) X-rays
6. Light with an energy flux of $25 \times 10^4 \text{ Wm}^{-2}$ falls on a perfectly reflecting surface at normal incidence. If the surface area is 15 cm^2 , the average force exerted on the surface is:
[2014]
(1) 1.25×10^{-6} N (2) 2.50×10^{-6} N (3) 1.20×10^{-6} N (4) 3.0×10^{-6} N
7. A parallel plate capacitor of capacitance $20\mu\text{F}$ is being charged by a voltage source whose potential is changing at the rate of 3 V/s. The conduction current through the connecting wires, and the displacement current through the plates of the capacitor, would be, respectively :
[NEET – 2019]
(1) zero, $60 \mu\text{A}$ (2) 60 mA, $60 \mu\text{A}$ (3) $60 \mu\text{A}$, zero (4) zero, zero
8. For a transparent medium relative permeability and permittivity, μ_r and ϵ_r are 1.0 and 1.44 respectively. The velocity of light in this medium would be,
[NEET – 2019 (ODISSA)]
(1) 2.5×10^8 m/s (2) 3×10^8 m/s (3) 2.08×10^8 m/s (4) 4.32×10^8 m/s
9. The E.M. wave with shortest wavelength among the following is
[NEET – 2020 (Covid-19)]
(1) Ultraviolet rays (2) X-rays (3) Gamma-rays (4) Microwaves

10. The magnetic field in a plane electromagnetic wave is given by : [NEET – 2020 (Covid-19)]
 $B_y = 2 \times 10^{-7} \sin(\pi \times 10^3 x + 3\pi \times 10^{11} t) \text{ T}$
 Calculate the wavelength.
 (1) $\pi \times 10^3 \text{ m}$ (2) $2 \times 10^{-3} \text{ m}$ (3) $2 \times 10^3 \text{ m}$ (4) $\pi \times 10^{-3} \text{ m}$
11. The ratio of contributions made by the electric field and magnetic field components to the intensity of an electromagnetic waves is : (c = speed of electromagnetic waves) [NEET – 2020 (Covid-19)]
 1) $1 : c^2$ 2) $c : 1$ 3) $1 : 1$ 4) $1 : c$
12. For a plane electromagnetic wave propagating in x-direction, which one of the following combination gives the correct possible direction for electric field I and magnetic field (2) respectively? [NEET-2021]
 1) $-j+k, -j-k$ 2) $j+k, -j-k$ 3) $-j+k, -j+k$ 4) $j+k, j+k$
13. When light propagates through a material medium of relative permittivity ϵ_r and relative permeability μ_r , the velocity of light, V is given by (c -velocity of light in vacuum) [NEET-2022]
 1) $v = c$ 2) $v = \sqrt{\frac{\mu_r}{\epsilon_r}}$ 3) $v = \sqrt{\frac{\epsilon_r}{\mu_r}}$ 4) $v = \frac{c}{\sqrt{\epsilon_r \mu_r}}$
14. Match List – I with List – II: [NEET-2022]
- | List – I
(Electromagnetic waves) | List – II
(Wavelength) |
|-------------------------------------|---------------------------|
| A) AM radio waves | i) 10^{-10} m |
| B) Microwaves | ii) 10^2 m |
| C) Infrared radiations | iii) 10^{-2} m |
| D) X-rays | iv) 10^{-4} m |
- Choose the correct answer from the options given below:
 1) (a)-(iv), (b)-(iii), c-(ii), (d)-(i) 2) (a)-(iii), (b)-(ii), c-(i), (d)-(iv)
 3) (a)-(iii), (b)-(iv), c-(ii), (d)-(i) 4) (a)-(ii), (b)-(iii), c-(iv), (d)-(i)

NCERT LINE BY LINE QUESTIONS – ANSWERS

1) d 2) d 3) d 4) a 5) b 6) d 7) d 8) c 9) b 10) c
 11) c 12) b 13) b 14) a 15) c 16) b 17) c 18) c 19) b 20) d

NCERT LINE BY LINE QUESTIONS – ANSWERS

1) C	2) A	3) C	4) A	5) B	6) D	7) A	8) A	9) B	10) C
11) A	12) B	13) A	14) C	15) A	16) C	17) B	18) C	19) A	20) C
21) B	22) A	23) C	24) C	25) B	26) B	27) C	28) D	29) C	30) D
31) A	32) C	33) A	34) B	35) A	36) B	37) B	38) D	39) A	40) D
41) A	42) B	43) B	44) A	45) D	46) A	47) A	48) A	49) B	50) B
51) C									

TOPIC WISE PRACTICE QUESTIONS - ANSWERS

1) 3	2) 3	3) 4	4) 3	5) 1	6) 2	7) 3	8) 3	9) 2	10) 1
11) 1	12) 2	13) 2	14) 3	15) 1	16) 3	17) 3	18) 1	19) 2	20) 3
21) 3	22) 4	23) 3	24) 2	25) 1	26) 4	27) 1	28) 1	29) 2	30) 1
31) 1	32) 1	33) 2	34) 2	35) 1	36) 4	37) 4	38) 2	39) 2	40) 1
41) 2	42) 2	43) 4	44) 2	45) 4	46) 3	47) 2	48) 2	49) 1	50) 4
51) 2	52) 1	53) 1	54) 1	55) 4	56) 1	57) 4	58) 2	59) 1	60) 4

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

1) 2	2) 1	3) 4	4) 1	5) 4	6) 2	7) 2	8) 1	9) 1	10) 2
11) 3	12) 1	13) 4	14) 4						

TOPIC WISE PRACTICE QUESTIONS - SOLUTIONS

- (3) $\lambda = c/v = 3 \times 10^8 \text{ ms}^{-1}/1000 \text{ s}^{-1}$
 $= 3 \times 10^5 \text{ m} = 300 \text{ km}$
- (3) Displacement current goes through the gap between the plates of a capacitor when the charge of the capacitor is zero
- (4) The speed of electromagnetic wave in a region is same for all intensities but different for different frequencies.

4. (3) The electromagnetic waves of all wavelengths travel with the same speed in space which is equal to velocity of light

5. (1) Direction of energy progradation of EM-waves is given by

$$\vec{D} = K(\vec{E} \times \vec{B}) \quad \text{or} \quad -\hat{k} = K(\hat{E} \times \vec{B})$$

Clearly direction of magnetic field is along positive x-axis.

6. (2) Displacement current flows in between capacitor plates only

7. (3) The direction of propagation of electromagnetic wave is perpendicular to the variation of electric field as $\vec{E}$ well as to the magnetic field $\vec{B}$

8. (3) $\oint \vec{B} \cdot d\vec{\ell} \sqrt{b^2 - 4ac} = \mu_0 \epsilon_0 \frac{d\phi}{dt}$

or $B \times 2\pi r = \mu_0 \epsilon_0 A \left(\frac{dE}{dt} \right) \quad \therefore B \propto \left(\frac{dE}{dt} \right)$

9. (2) Momentum per unit time per unit area $= \frac{\text{intensity}}{\text{speed of wave}} = \frac{I}{c}$

Change in momentum per unit time per unit area $= \Delta I/c =$ radiation pressure (P), i.e. $P = \Delta I/c$.
Momentum of incident wave per unit time per unit area $= I/c$

When wave is fully absorbed by the surface, the momentum of the reflected wave per unit time per unit area $= 0$

Radiation pressure (P) = change in momentum per unit time per unit area $= \frac{\Delta I}{c} = \frac{I}{c} - 0 = \frac{I}{c}$

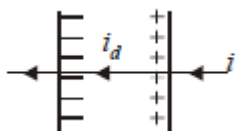
When wave is totally reflected, then momentum of the reflected wave per unit time per unit area $= -I/c$.

Radiation pressure (P) $= \frac{I}{c} - \left(-\frac{I}{c} \right) = \frac{2I}{c}$

Here, P lies between $\frac{I}{c}$ and $\frac{2I}{c}$.

10. (1) $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{8.2 \times 10^6} = 36.5 \text{ m}$

11. (1) According to conservation of charge, the displacement current must be leftward.



12. (2) An electromagnetic wave has both energy and momentum.

13. (2) EM waves carry energy (light), momentum (can be seen by photoelectric experiment) and information (like radio waves) but doesn't carry charge.

14. (3) The energy in an electromagnetic wave is tied up in the electric and magnetic fields. In general, the energy per unit volume in an electric field is given by:

$$\text{energy density in electric field} = \frac{1}{2} \epsilon_0 E^2$$

In a magnetic field, the energy per unit volume is:

$$\text{energy density in magnetic field} = \frac{1}{2\mu_0} B^2$$

An electromagnetic wave has both electric and magnetic fields, so the total energy density associated with an electromagnetic wave is:

$$u = \frac{1}{2} \epsilon_0 E^2 + \frac{1B^2}{2\mu_0}$$

It turns out that for an electromagnetic wave, the energy associated with the electric field is equal to the energy associated with the magnetic field, so the energy density can be written in terms of just one or the other:

$$u = \frac{1}{2} \epsilon_0 E^2 = \frac{1B^2}{2\mu_0}$$

This also implies that in an electromagnetic wave, $E = cB$.

15. (1). Energy density (EM waves)

$$= \epsilon_0 E_{\text{rms}}^2 = \epsilon_0 \left(\frac{E_0}{\sqrt{2}} \right)^2 = \frac{1}{2} \epsilon_0 E_0^2$$

16. (3) Incident momentum, $p = \frac{E}{c}$

For perfectly reflecting surface with normal incidence

$$\Delta p = 2p = \frac{2E}{c} \quad F = \frac{\Delta p}{\Delta t} = \frac{2E}{ct} \quad P = \frac{F}{A} = \frac{2E}{ctA}$$

17. (3) Speed of EM waves in vacuum $= \sqrt{\mu_0 \epsilon_0} = \text{constant}$

18. (1) Electromagnetic waves are transverse in nature as is evident by polarization interference and diffraction explain the wave nature of light or EM waves polarization is the phenomenon by which we restrict the vibration of wave in a particular direction perpendicular to direction of W are propagation. So, it explains the transverse nature of EM waves.

19. (2) From question,

$$B_0 = 20 \text{ nT} = 20 \times 10^{-9} \text{ T}$$

$$(\because \text{velocity of light in vacuum } C = 3 \times 10^8 \text{ ms}^{-1})$$

$$\vec{E}_0 = \vec{B}_0 \times \vec{C} \quad |\vec{E}_0| = |\vec{B}_0| \cdot |\vec{C}| = 20 \times 10^{-9} \times 3 \times 10^8 = 6 \text{ V/m}$$

20. (3) Magnetic field vector, $\vec{B} = \frac{2E_0}{c} \hat{j} \sin kz \sin \omega t$

21. (3) Speed of light of vacuum $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$ and in another medium $v = \frac{1}{\sqrt{\mu \epsilon}}$

$$\therefore \frac{c}{v} = \sqrt{\frac{\mu \epsilon}{\mu_0 \epsilon_0}} = \sqrt{\mu_r K} \Rightarrow v = \frac{c}{\sqrt{\mu_r K}}$$

22. (4) Any stationary charge produce static electric field. And the field strength is given by:
r, is the radial distance from the point charge.

Q, is the charge in Coulomb.

When electric charge oscillates electric field at any point also oscillates. And according to Maxwell's equations varying electric field produces magnetic field and an oscillating electric field produces oscillating magnetic field.

This thing is used in antennas in which oscillating current of certain frequency produces oscillating electric and magnetic field which propagates through space (electromagnetic waves).

23. (3) According to Maxwell, a changing electric field is a source of magnetic field.

24. (2) As we know, $\vec{E} \cdot \vec{B} = 0 \quad \because [\vec{E} \perp \vec{B}]$

and $\vec{E} \times \vec{B}$ should be along Z direction

$$\text{As } (-2\hat{i} - 3\hat{j}) \times (3\hat{i} - 2\hat{j}) = 5\hat{k}$$

Hence option (2) is the correct answer.

25. (1) $2.98 \times 10^8 \text{ NC}^{-1} \text{ T}^{-1}$

26. (4) Conduction current flows through wires, resistance and capacitor

27. (1) $I_D = \epsilon_0 d\phi_E / dt$

28. (1) Here, $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{5.2 \times 10^6} = 57.6 \text{ m}$

29. (2) Here, $E_0 = 18 \text{ V/m}$; $B_0 = ?$

$$B_0 = \frac{E_0}{c} = \frac{18}{3 \times 10^8} = 6 \times 10^{-8} \text{ T}$$

30. (1) Here, amplitude of electric field, $E_0 = 100 \text{ V/m}$; amplitude of magnetic field, $H_0 = 0.265 \text{ A/m}$. We know that the maximum rate of energy flow,
 $S = E_0 \times H_0 = 100 \times 0.265 = 26.5 \text{ W/m}^2$.

31. (1) Velocity of light

$$C = \frac{E}{B} \Rightarrow B = \frac{E}{C} = \frac{9.3}{3 \times 10^8} = 3.1 \times 10^{-8}$$

32. (1) The speed of light

$$C = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = \frac{1}{\sqrt{2 \times 8}} = \frac{1}{4} = 0.25$$

33. (2) For electromagnetic waves we know that, $\frac{E}{B} = c$

$$\therefore \frac{9 \times 10^{-4}}{B} = 3 \times 10^8 \text{ ms}^{-1} \quad b = 3 \times 10^{-12} \text{ T}$$

34. (2) remains constant

35. (1) $E_{\text{rms}} = 720$

The average total energy density

$$= \frac{1}{2} \epsilon_0 E_0^2 = \frac{1}{2} \epsilon_0 \left[\sqrt{2} E_{\text{rms}} \right]^2 = \epsilon_0 E_{\text{rms}}^2$$

$$= 8.85 \times 10^{-12} \times (720)^2 = 4.58 \times 10^{-6} \text{ J/m}^3$$

36. (4) $I_d = 1 \text{ mA} = 10^{-3} \text{ A}$

$$C = 2 \mu\text{F} = 2 \times 10^{-6} \text{ F}$$

$$I_D = I_C = \frac{d}{dt}(CV) = C \frac{dV}{dt}$$

$$\text{Therefore, } \frac{dV}{dt} = \frac{I_D}{C} = \frac{10^{-3}}{2 \times 10^{-6}} = 500 \text{ Vs}^{-1}$$

Therefore, applying a varying potential difference of 500 V s^{-1} would produce a displacement current of desired value.

37. (4) Given: The magnetic field of the plane electromagnetic wave is $1.2 \times 10^{-8} \hat{k}$ T

The direction of propagation of the electromagnetic wave is along X-direction.

The magnitude of E is given by:

$$E = B \cdot c = (1.2 \times 10^{-8} \text{ T})(3 \times 10^8 \text{ ms}^{-1}) = 3.6 \text{ V/m}$$

Since the magnetic field is along Z-direction and the wave propagates along X-direction. Therefore E should be in a direction perpendicular to both X and Z axes.

Using vector algebra should be along X-direction.

$$\text{Since } (+\hat{j}) \times (\hat{k}) = \hat{i}$$

E is along the Y-direction.

$$\text{Thus, } \vec{E} = 3.6 \hat{j} \text{ Vm}^{-1}$$

38. (2) $\omega = 2\pi\nu = \frac{2\pi c}{\lambda} = \frac{2\pi \times 3 \times 10^8}{3 \times 10^{-3}} = 2\pi \times 10^{11} \text{ rad/sec}$

The equation for the electric field, along y-axis in the electromagnetic wave is

$$E_y = E_0 \sin \omega \left(t - \frac{x}{c} \right)$$

$$= 10 \sin \left[2\pi \times 10^{11} \left(t - \frac{x}{c} \right) \right]$$

39. (2) The range of visible radiations is 4000 Å to 8000 Å

40. (1) Cosmic rays are coming from outer space, having high energy charged particles, like α -particle, proton etc. β -rays are stream of high energy electrons, coming from the nucleus of radioactive atoms.

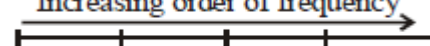
41. (2) Ultra violet rays are used to sterilise milk as their wavelengths are shorter than visible rays and at small wavelengths they can break molecular bonds within DNA of bacteria (present in milk) thereby killing or disabling them

42. (2) Point contact diodes, commonly called crystals, are the oldest microwave semiconductor devices. Unlike the pn-junction diode, the point-contact diode depends on the pressure of contact between a point and a semiconductor crystal for its operation. One section of the diode consists of a small rectangular crystal of n-type silicon. A fine beryllium-copper, bronze-phosphor, or tungsten wire presses against the crystal and forms the other part of the diode. During the manufacture of the point contact diode, a relatively large current is passed from the wire to the silicon crystal. The result of this large current is the formation of a small region of p-type material around the crystal in the vicinity of the point contact. Thus, a pn-junction is formed which behaves in the same way as a normal pn-junction. The pointed wire is used instead of a flat metal plate to produce a high-intensity electric field at the point contact without using a large external source voltage.

43. (4) $\nu_\gamma\text{-rays} > \nu_{\text{visible radiation}} > \nu_{\text{infrared}} > \nu_{\text{Radio waves}}$

44. (2) Infrared radiations reflected by low lying clouds and keeps the earth warm.

45. (4) $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{1240 \text{ eVnm}}{2.06 \text{ eV}} \Rightarrow \lambda = 6000 \text{ Å}$

Increasing order of frequency

 x-rays u-v rays visible Infrared

wavelength range of visible region is 4000 Å to 7800 Å.

46. (3) The electromagnetic spectrum consists of radio waves, micro waves, infrared waves, visible light, ultra violet rays, x rays and γ rays. So, correct answer is option (3), i.e. α rays.

47. (2) X-rays are used for the investigation of structure of solids.

48. (2) Depends on the magnitude of frequency

49. (1) $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{11 \times 1000 \times 1.6 \times 10^{-19}} = 12.4 \text{ Å}$

50. (4) $V_s = V_x = V_m$
51. (2) Infrared camera enables vision in the infrared region of the spectra, unlike that in normal cameras where photography is limited to visible spectrum. Thermal infrared images let us see heat and how it is distributed. A thermal infrared camera detects infrared energy and converts it into an electronic signal, which is then processed to produce a thermal image and perform temperature calculations. Thermal imaging cameras have lenses, just like visible light cameras. It can thus be used to see living objects in the night time, when visibility vanishes in the visible spectrum.
52. (1) The basic source of electromagnetic radiation is an accelerated charge
53. (1) The ozone layer converts the ultraviolet radiation to Infrared ray
54. (1) In vacuum velocity of all EM waves are same but their wavelengths are different.
55. (4) $\lambda_{\text{Radio wave}} > \lambda_{\text{IR rays}} > \lambda_{\text{UV rays}} > \lambda_{\text{x-rays}}$
56. (1) The Ozone layer absorbs Electromagnetic radiations which have wavelength less than $3 \times 10^{-5} \text{ m}$ or frequency more than 10^{13} Hz
57. (4) The frequency of television signal is smaller than that of microwave and visible waves.
58. (2) In the image we can see that radio waves have longest wavelength and lowest frequency Visible light
59. (1) Radio waves are reflected by ionosphere.
60. (4) Now a days microwaves are used to locate the flying objects by Radar.

NEET PREVIOUS YEARS QUESTIONS-EXPLANATIONS

1. (2) Direction of oscillating magnetic field of e.m. wave will be perpendicular to electric field and wave propagation direction.
2. (1) Given, $E_{\text{rms}} = 6 \text{ V/m}$

$$\frac{E_{\text{rms}}}{B_{\text{rms}}} = c \Rightarrow B_{\text{rms}} = \frac{E_{\text{rms}}}{c} \quad \dots(i)$$

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

$$B_0 = \sqrt{2} \times \frac{E_{\text{rms}}}{C} \quad \text{From equation (i)}$$

$$= \frac{\sqrt{2} \times 6}{3 \times 10^8} = 2.83 \times 10^{-8} \text{ T}$$

3. (4) To generate electromagnetic waves we need accelerating charge particle.
4. (1) Momentum of light falling on reflecting surface $p = \frac{E}{C}$

As surface is perfectly reflecting so momentum reflect $p^l = \frac{E}{C}$



So, momentum transferred

$$= P - p^l = \frac{E}{C} - \left(-\frac{E}{C} \right) = \frac{2E}{C}$$

5. (4) Energy of x-ray is (100 ev to 100 kev)

Hence energy of the order of 15 keV belongs to x-rays.

$$6. \quad (2) \text{ Average force } F_{av} = \frac{\Delta p}{\Delta t} = \frac{2IA}{c} \quad (\because \text{Power} = F.V)$$

$$7. \quad V = Q/C \text{ or } Q = CV$$

$$\therefore i = C \frac{dV}{dt} = 20 \mu F \times 3V/s = 60 \mu A$$

Also, conduction current in wires is equal to displacement current between the plates of capacitor.

$$8. \quad v = \frac{1}{\sqrt{\mu\epsilon}} = \frac{1}{\sqrt{\mu_r \epsilon_r \mu_0 \epsilon_0}}$$

$$= \frac{3 \times 10^8}{\sqrt{1.44}} = \frac{30}{12} \times 10^8 = 2.5 \times 10^8 \text{ ms}^{-1}$$

9. Gamma rays have shortest wavelength among all options.

$$10. \quad \lambda = \frac{2\pi}{K} = \frac{2\pi}{\pi \times 10^3} = 2 \times 10^{-3} \text{ m}$$

$$11. \quad I = u_{avg} \times C$$

$$u_{avg} B = \frac{B_0^2}{4\mu_0}$$

$$u_{avg} E = \frac{1}{2} \epsilon_0 E_0^2 \quad (\because u_{avg} B = u_{avg} E)$$

$$= \frac{1}{4} \epsilon_0 B_0^2 c^2 \quad (\text{For the intensity of wave, EF and M.F contribute equally})$$

$$\Rightarrow \frac{1}{4} (\epsilon_0 c^2) B_0^2$$

$$\Rightarrow \frac{1}{4} \frac{1}{\mu_0} B_0^2$$

$$u_{avg} E = \frac{B_0^2}{4\mu_0}$$

$$13. \quad \frac{C}{v} = \sqrt{\mu r \epsilon r}$$

$$v = \frac{C}{\sqrt{\mu r \epsilon r}}$$

$$14. \quad \text{AM radio waves} = 10^2 \text{ m} > 0.1 \text{ m}$$

$$\text{Micro waves} = 0.1 \text{ to } 1 \text{ mm}$$

$$\text{Infrared rays} = 1 \text{ mm to } 700 \text{ nm}$$

$$\text{X-rays} = 1 \text{ nm to } 10^{-3} \text{ nm}$$