Exercise-1

✍ **Marked Questions can be used as Revision Questions.**

OBJECTIVE QUESTIONS

1. The fundamental source of e. m. waves

(1) is varying magnetic field (2) constant magnetic and electric fields

(3) are continous oscillations of electric charge (4) is planets

2.✍ The speed of e. m. waves is given by the relation

(1) $\mu_0 \varepsilon_0$ (2) $\sqrt{\mu_0 \varepsilon_0}$ (3) $1/\mu_0 \varepsilon_0$ (4) $1/\sqrt{(\mu_0 \varepsilon_0)}$

3. In an electromagnetic wave, electric field **E** and magnetic field **B** are

(1) mutually perpendicular to each other (2) all parallel

(3) at 30^0 to each other (4) at 60^0 to each other

4. If $\vec{E}$ and $\vec{B}$ be the electric and magnetic fields of electromagnetic 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 the above

5. Red light differs from blue light in its

(1) speed. (2) frequency (3) intensity (4) amplitude

6. The electromagnetic waves used in the telecommunication are

(1) ultraviolet (2) infra-red (3) visible (4) microwaves.

7.✍ If an electromagnetic wave propagating through vacuum is described by

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

(1) $E_0 k = B_0 \omega$ (2) $E_0 B_0 = \omega k$ (3) $E_0 \omega = B_0 k$ (4) $E_0 B_0 = \omega / k$

8. Which of the following rays are not electromagnetic waves ?

(1) β – rays (2) Heat rays (3) X- rays (4) γ–rays

9.✍ The frequency of light wave in a material is 2×10^{14} Hz and wavelength is 5000 Å. The refractive index of material will be :

(1) 1.40 (2) 1.50 (3) 3.00 (4) 1.33

10. The electric and magnetic field of an electromagnetic wave are :

(1) in phase and parallel to each other

(2) in opposite phase and perpendicular to each other

(3) in opposite phase and parallel to each other

(4) in phase and perpendicular to each other.

11. The electric field part of an electromagnetic wave in a medium is represented by

$E_x = 0$;

$$E_y = 2.5\frac{N}{C}\cos\left[\left(2\pi\times10^6\frac{rad}{s}\right)t-\left(\pi\times10^{-2}\frac{rad}{m}\right)x\right]$$

$E_z = 0$. The wave is :

(1) moving along y direction with frequency $2\pi \times 10^6$ Hz and wavelength 200 m.

(2) moving along x direction with frequency 10^6 Hz and wavelength 100m

(3) moving along x direction with frequency 10^6 Hz and wavelength 200m

(4) moving along –x direction with frequency 10^6 Hz and wavelength 200m

12. The electric field of an electromagnetic wave in free space is given by $\vec{E} = 10\cos(10^7 t + kx)\hat{j}$ V/m, where t and x are in seconds and metres respectively. It can be inferred that

(i) the wavelength λ is 188.4 m.

(ii) the wave number k is 0.33 rad/m

(iii) the wave amplitude is 10 V/m

(iv) the wave is propagating along +x direction

Which one of the following pairs of statements is correct ?

(1) (iii) and (iv)

(2) (i) and (ii)

(3) (ii) and (iii)

(4) (i) and (iii)

13. Maxwell's equation describe the fundamental laws of

(1) electricity only (2) magnetism only (3) mechnaics only (4) both (1) and (2)

14. An electromagnetic wave going through vacuum is described by $E = E_0 \sin(kx - \omega t)$. Which of the following is/are independent of the wavelength ?

(1) k (2) ω (3) k/ω (4) $k\omega$

15. The energy contained in a small volume through which an electromagnetic wave is passing oscillates with

(1) zero frequency

(2) the frequency of the wave

(3) half the frequency of the wave

(4) double the frequency of the wave

16. A parallel-plate capacitor with plate area A and separation between the plates d, is charged by a constant current i. Consider a plane surface of area A/2 parallel to the plates and drawn symmetrically between the plates. Find the displacement current through this area.

(1) i (2) $\frac{i}{2}$ (3) 2i (4) zero

17.✍ A light beam travelling in the x-direction is described by the eletric field E_y = (300 V/m) $\sin\omega(t - x/c)$. An electron is constrained to move along the y-direction with a speed of 2.0×10^7 m/s. The maximum electric force and the maximum magnetic force on the electron are-

(1) 4.8×10^{-17} N,zero (2) 4.2×10^{-18} N, 1.8×10^{-8}

(3) 4.8×10^{-17} N,3.2×10^{-18} N (4) zero, zero

18. Find the energy stored in a 60 cm length of a laser beam operating at 4 mW.

(1) 8×10^{-12}J (2) 6×10^{-12}J (3) 4×10^{-12}J (4) 7×10^{-12}J

19.✍ A parallel-plate capacitor having plate area A and plate separation d is joined to a battery of emf e and internal resistance R at t = 0 consider a plane surface of area A/2 parallel to the plates and situated symmetrically between them. Find the displacement current through this surface as a function of time.

(1) $\frac{\varepsilon}{2R}e^{\frac{-td}{\varepsilon AR}}$ (2) $\frac{\varepsilon}{R}e^{\frac{-td}{\varepsilon AR}}$ (3) $\frac{2\varepsilon}{R}e^{\frac{-td}{\varepsilon AR}}$ (4) $\frac{\varepsilon}{2R}e^{\frac{-2td}{\varepsilon AR}}$

20. If E denotes the intensity of electric field, the dimensions of a quantity $\epsilon_0 \frac{dE}{dt}$ are those of

(1) current (2) current density (3) electric potential (4) electric flux

21. In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of 2.5×10^{10} Hz and amplitude 480 V/m. The amplitude of the oscillating magnetic field will be

(1) 1.52×10^{-8} Wb/m^2 (2) 1.52×10^{-7} Wb/m^2 (3) 1.6×10^{-6} Wb/m^2 (4) 1.6×10^{-7} Wb/m^2

22. If ε_0 and μ_0 represent the permittivity and permeability of vacuum and ε and μ represent the permittivity and permeability of medium, the refractive index of the medium is given by

(1) $\sqrt{\frac{\varepsilon_0\mu_0}{\varepsilon\mu}}$ (2) $\sqrt{\frac{\varepsilon\mu}{\varepsilon_0\mu_0}}$ (3) $\sqrt{\frac{\varepsilon}{\mu_0\varepsilon_0}}$ (4) $\sqrt{\frac{\mu_0\varepsilon_0}{\varepsilon}}$

23. A flood light is covered with a fitter that transmits red light. The electric field of the emerging beam is represented by a sinusoidal plane wave

$E_x = 36 \sin (1.20 \times 10^7 z - 3.6 \times 10^{15} t)$ V/m

The average intensity of beam in W/m^2 will be

(1) 6.88 (2) 3.44 (3) 1.72 (4) 0.86

24. A lamp emits monochromatic green light uniformly in all directions. The lamp is 3% electrical in converting electrical power to electromagnetic waves and consumes 100W of power. The amplitude of the electric field associated with the electromagnetic radiation at a distance of 5m from the lamp will be

(1) 1.34 V/m (2) 2.68 V/m (3) 4.02 V/m (4) 5.36 V/m

25. A point source of electromagnetic radiation has an average power output of 800W. The maximum value of electric field at a distance 4.0 m from the source is

(1) 64.7 V/m (2) 57.8 V/m (3) 56.72 V/m (4) 54.77 V/m

26. The average energy-density of electromagnetic wave given by E = (50 N/C) sin (ωt – kx) will be nearly

(1) 10^{-8} J/m^3 (2) 10^{-7} J/m^3 (3) 10^{-6} J/m^3 (4) 10^{-5} J/m^3

27. A plane electromagnetic wave travelling along the X-direction has a wavelength of 3mm. The variation in the electric field occurs in the Y-direction with an amplitude 66 Vm^{-1}. The equation for the electric and magnetic fields as a function of x and t are respectively.

(1) $E_y = 33\cos \pi \times 10^{11}\left(t-\frac{x}{c}\right)$, $B_z = 1.1 \times 10^{-7} \cos \pi \times 10^{11}\left(t-\frac{x}{c}\right)$

(2) $E_y = 11\cos 2\pi \times 10^{11}\left(t-\frac{x}{c}\right)$, $B_y = 11 \times 10^{-7} \cos 2\pi \times 10^{11}\left(t-\frac{x}{c}\right)$

(3) $E_x = 33\cos \pi \times 10^{11}\left(t-\frac{x}{c}\right)$, $B_x = 11 \times 10^{-7} \cos \pi \times 10^{11}\left(t-\frac{x}{c}\right)$

(4) $E_y = 66\cos 2\pi \times 10^{11}\left(t-\frac{x}{c}\right)$, $B_z = 2.2 \times 10^{-7} \cos 2\pi \times 10^{11}\left(t-\frac{x}{c}\right)$

(5) $E_y = 66\cos \pi \times 10^{11}\left(t-\frac{x}{c}\right)$, $B_y = 2.2 \times 10^{-7} \cos \pi \times 10^{11}\left(t-\frac{x}{c}\right)$

28. If the wavelength of light is 4000 Å, then the number of waves in 1mm length will be

(1) 25 (2) 0.25 (3) 0.25×10^4 (4) 25×10^4

29. The electric field associated with an electromagnetic wave in vacuum is given by $\vec{E} = \hat{i}40\cos$ (kz – 6 × 10^8t), where E, z and t are in volt/m, meter and seconds respectively. The value of wave vector k is

(1) 2m^{-1} (2) 0.5 m^{-1} (3) 6 m^{-1} (4) 3 m^{-1}

30. Electromagnetic waves can be deflected by

(1) Electric field only (2) Magnetic field only (3) Both (a) and (b) (4) None of these

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

(1) A visible light (2) An infrared wave (3) A microwave (4) A radio wave

Exercise-2

Marked Questions can be used as Revision Questions.

COMPREHENSION

Comprehension :

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

1. What is the wavelength of the wave ?

(1) 1.5×10^{-2} m (2) 2.5×10^{-2} m (3) 1.5×10^{-3} m (4) 2.5×10^{-3} m

2. What is the amplitude of the oscillating magnetic field?

(1) 2.7×10^{-7} T (2) 1.6×10^{-7} T (3) 1.6×10^{-8} T (4) 2.7×10^{-8} T

Exercise-3

Marked Questions can be used as Revision Questions.

PART - I : AIEEE PROBLEMS (PREVIOUS YEARS)

1. Infrared radiation is detected by **[AIEEE 2002; 3/225, –1]**

(1) spectrometer (2) pyrometer (3) nanometer (4) photometer

2. Dimensions of $\frac{1}{\mu_0 \epsilon_0}$, where symbols have their usual meanings, are **[AIEEE 2003; 3/225, –1]**

(1) $[L^{-1} T]$ (2) $[L^{-2} T^2]$ (3) $[L^2 T^{-2}]$ (4) $[L T^{-1}]$

3. Which of the following radiations has the least wavelength ? **[AIEEE 2003; 3/225, –1]**

(1) γ-rays (2) β-rays (3) α-rays (4) X-rays

4. An electromagnetic wave of frequency n = 3.0 MHz passes vacuum into a dielectric medium with permittivity $\varepsilon = 4.0$, then **[AIEEE 2004; 3/225, –1]**

(1) wavelength is doubled and the frequency remains unchanged

(2) wavelength is doubled and frequency becomes half

(3) wavelength is halved and frequency remains unchanged

(4) wavelength and frequency both remain unchanged

5. An electromagnetic wave in vacuum has the electric and magnetic field $\vec{E}$ 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, 4/120, – 1]**

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

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

6. 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, 4/120, –1]**

(1) 3V/m (2) 6V/m (3) 9V/m (4) 12 V/m

7. This question has statement–1 and statement–2. Of the four choices given after the statements, choose the one that best describes the two statements. **[JEE(MAIN) 2013_ONLINE TEST]**

Statement–1 : Out of radio waves and microwaves, the radio waves undergo more diffraction.

Statement–2 : Radio waves have greater frequency compared to microwaves.

(1) Statement–1 is true, Statement –2 is false

(2) Statement–1 is false, Statement –2 is true

(3) Both statements are true and statement–2 is correct explanation of statement–1

(4) Both statements are true and statement–2 is not correct explanation of statement–1

8. During the propagation of electromagnetic waves in a medium : **[JEE (Main) 2014, 4/120, –1]**

(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.

9.✍ Match List-I (Electromagnetic wave type) with List-II (Its association/application) and select the correct option from the choices given below the lists : **[JEE (Main) 2014, 4/120, –1]**

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

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

10. Match List–I (Wavelength range of electromagnetic spectrum) with List–II. (Method of production of these waves) and select the correct option from the options given below the lists **[JEE (MAIN) 2014_ONLINE TEST]**

List–I		**List –II**	
(a)	700 nm to 1mm	(i)	Vibration of atoms and molecules
(b)	1nm to 400 nm	(ii)	inner shell electrons in atoms moving from one one energy level to a lower level
(c)	< 10^{-3} nm	(iii)	Radioactive decay of the molecules
(d)	1mm to 0.1 m	(iv)	Magnetron valve

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

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

11. Match the List–I (Phenomenon associated with electromagnetic radiation) with List–II (Part of electromagnetic spectrum) and select the correct code from the choices given below the lists : **[JEE (MAIN) 2014_ONLINE TEST]**

	List–I		List –II
I	Doublet of sodium	A	visible radiation
II	Wavelength corresponding to temperature associated with the isotropic radiation filling all space	B	Microwave
III	Wavelength emitted by atomic hydrogen in interstellar space	C	Short radiowaves
IV	Wavelength of radiation arising from the two close energy level in hydrogen	D.	X–rays

(1) (I) – (B), (II) – (A), (III), (D), (IV)– (A)
(2) (I) – (A), (II) – (B), (III), (B), (IV)– (C)
(3) (I) – (A), (II) – (B), (III), (C), (IV)– (C)
(4) (I) – (D), (II) – (C), (III), (A), (IV)– (B)

12. An electromagnetic wave of frequency 1×10^{14} hertz is propagating along z–axis. The amplitude of electric field is 4V/m. If $\in_0 = 8.8 \times 10^{-12}$ $C^2/N–m^2$, then average energy density of electric field will be :
[JEE (Main) 2014_ONLINE TEST]

(1) 35.2×10^{-11} J/m^3 (2) 35.2×10^{-12} J/m^3 (3) 35.2×10^{-13} J/m^3 (4) 35.2×10^{-10} J/m^3

13. If denote microwaves, X rays, infrared, gamma rays, ultra–violet, radio waves and visible parts of the electromagnetic spectrum by M, X, I, G, U, R and V, the following is the arrangement in ascending order of wavelength : **[JEE (Main) 2014_ONLINE TEST]**

(1) I, M, R, U, V, X and G
(2) R, M, I, V, U, X and G
(3) M, R, V, X, U, G and I
(4) G, X, U, V, I, M and R

14. An electromagnetic wave travelling in the x-direction has frequency of 2×10^{14} Hz and electric field amplitude of 27 Vm^{-1}. From the options given below, which one describes the magnetic field for this wave ? **[JEE (Main) 2015_ONLINE TEST]**

(1) $\vec{B}(x,\ t) = (9 \times 10^{-8} T)\hat{j}$ $\sin\left[1.5 \times 10^{-6} x - 2 \times 10^{14} t\right]$

(2) $\vec{B}(x,\ t) = (9 \times 10^{-8} T)\hat{i}$ $\sin\left[2\pi(1.5 \times 10^{-8} x - 2 \times 10^{14} t)\right]$

(3) $\vec{B}(x,\ t) = (9 \times 10^{-8} T)\hat{k}$ $\sin\left[2\pi(1.5 \times 10^{-6} x - 2 \times 10^{14} t)\right]$

(4) $\vec{B}(x,\ t) = (3 \times 10^{-8} T)\hat{j}$ $\sin\left[2\pi(1.5 \times 10^{-8} x - 2 \times 10^{14} t)\right]$

15. 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 ? **[JEE (Main) 2015_ONLINE TEST]**

(1) $\left(2\hat{i} + 3\hat{j}\right)$ and $\left(\hat{i} + 2\hat{j}\right)$
(2) $\left(-2\hat{i} - 3\hat{j}\right)$ and $\left(3\hat{i} - 2\hat{j}\right)$
(3) $\left(3\hat{i} + 4\hat{j}\right)$ and $\left(4\hat{i} - 3\hat{j}\right)$
(4) $\left(\hat{i} + 2\hat{j}\right)$ and $\left(2\hat{i} - \hat{j}\right)$

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

A : Blue light B : Yellow light **[JEE (Main) 2016 ; 4/120, –1]**

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

17. 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 υ 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)-2018,4/120,–1]**

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

Answers

EXERCISE-1

1.	(3)	**2.**	(4)	**3.**	(1)
4.	(3)	**5.**	(2)	**6.**	(4)
7.	(1)	**8.**	(1)	**9.**	(3)
10.	(4)	**11.**	(3)	**12.**	(4)
13.	(4)	**14.**	(3)	**15.**	(4)
16.	(2)	**17.**	(3)	**18.**	(1)
19.	(1)	**20.**	(2)	**21.**	(3)
22.	(2)	**23.**	(3)	**24.**	(2)
25.	(4)	**26.**	(1)	**27.**	(4)
28.	(3)	**29.**	(1)	**30.**	(4)
31.	(3)				

EXERCISE-2

1.	(1)	**2.**	(2)

EXERCISE-3

PART – I

1.	(2)	**2.**	(3)	**3.**	(1)
4.	(3)	**5.**	(2)	**6.**	(2)
7.	(1)	**8.**	(3)	**9.**	(4)
10.	(1)	**11.**	(2)	**12.**	(2)
13.	(4)	**14.**	(3)	**15.**	(2)
16.	(4)	**17.**	(1)		