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IIT/PMT INSTITUTE

CHAPTER TEST

Subject : Physics **Topic : Electromagnetic Waves** **M.M. : 180**

Have patience all things are difficult before they become easy.

Marking Scheme:

(i) Each question is allotted 4 (four) marks for each correct response.

(ii) ¼ (one fourth) marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.

Q.1 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

(A) $1.2\,\hat{j}$ (B) $3.6\,\hat{k}$

(C) $1.2\,\hat{k}$ (D) $3.6\,\hat{j}$

Q.2 In order to establish an instantaneous displacement current of 1mA in the space between the plates of 2μF parallel plate capacitor, the potential difference need to apply is –

(A) 100 V/s (B) 200 V/s

(C) 300 V/s (D) 500 V/s

Q.3 If μ_0 be the permeability and ε_0 be the permittivity of a medium then its refractive index is given by

(A) $\frac{1}{\sqrt{\mu_0\varepsilon_0}}$ (B) $\frac{1}{\mu_0\varepsilon_0}$

(C) $\sqrt{\mu_0\varepsilon_0}$ (D) $\mu_0\varepsilon_0$

Q.4 Electromagneticwave consists of periodically oscillating electric and magnetic vectors .

(A) in mutually perpendicular planes but vibrating with a phase difference of π.

(B) in mutually perpendicular planes but vibrating with a phase difference of π/2.

(C) in randomly oriented planes but vibrating in phase.

(D) in mutually perpendicular planes but vibrating in phase.

Q.5 Which of the following has/have zero average value in a plane electromagnetic wave?

(A) Both magnetic and electric fields.

(B) Electric field only

(C) Magnetic field only

(D) None of these

Q.6 The crystal structure can be studied by using

(A) UV rays (B) X-rays

(C) IR radiation (D) Microwaves

Q.7 Which of the following electromagnetic wave play an important role in maintaining the earth's warmth or average temperature through the green house effect?

(A) Visible rays (B) Infrared waves

(C) Gamma rays (D) Ultraviolet rays

Q.8 X-rays, gamma rays and microwaves travelling vacuum have

(A) same wavelength but different velocities.

(B) same frequency but different velocities.

(C) same velocity but different wavelengths.

(D) same velocity and same frequency.

Q.9 One requires 11eV 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.

Q.10 A linearly polarized electromagnetic wave given as $\vec{E} = E_0\hat{i}\cos(kz - \omega t)$ is incident normally on a perfectly reflecting infinite wall at z = a. Assuming that the material of the wall is optically inactive, the reflected wave will be given as

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

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

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

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

Q.11 The electric field intensity produced by the radiations coming from 100 W bulb at a 3m distance is E. The electric field intensity produced by the radiations coming from 50 W bulb at the same distance is –

(A) E/2 (B) 2E

(C) $E/\sqrt{2}$ (D) $\sqrt{2}E$

Q.12 During the propagation of electromagnetic waves in a medium:

(A) Electric energy density is equal to the magnetic energy density.

(B) Both electric and magnetic energy densities are zero.

(C) Electric energy density is double of the magnetic energy density.

(D) Electric energy density is half of the magnetic energy density.

Q.13 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) $c^{1/2}$:1

Q.14 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) $1/r^3$ (B) $1/r^2$

(C) 1/r (D) remains constant.

Q.15 If the total energy transferred to a surface in time t is u, then the magnitude of the total momentum delivered to this surface (for complete absorption) is –

(A) P = u/c (B) P = c/u

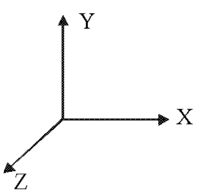
(C) P = cu (D) P = 2c/u

Q.16 A red LED emits light at 0.1 watt uniformly around it. The amplitude of the electric field of the light at a distance of 1 m from the diode is

(A) 2.45 V/m (B) 5.48 V/m

(C) 7.75 V/m (D) 1.73 V/m

Q.17 Light wave is travelling along y-direction. If the corresponding E vector at any time is along the X-axis, the direction of B vector at that time is along



(A) Y-axis (B) X-axis

(C) +Z-axis (D) –Z-axis

Q.18 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 –

(A) 4.58×10^{-6} J/m^3 (B) 6.37×10^{-9} J/m^3

(C) 81.35×10^{-12} J/m^3 (D) 3.3×10^{-3} J/m^3

Q.19 Which of the following relation is correct ?

(A) $\sqrt{\varepsilon_0 E_0} = \sqrt{\mu_0 B_0}$ (B) $\sqrt{\mu_0 \varepsilon_0} E_0 = B_0$

(C) $E_0 = \sqrt{\mu_0 \varepsilon_0} B$ (D) $\sqrt{\mu_0} E_0 = \sqrt{\varepsilon_0} B_0$

Q.20 Match List-I (Electromagnetic wave type) with List-II (Its association / application) and select the correct option from the choices given the lists:

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

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

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

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

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

Q.21 If λ_v, λ_x & λ_m respresent the wavelengts of visible light, X-rays and microwaves respectively, then –

(A) $\lambda_m > \lambda_x > \lambda_v$ (B) $\lambda_m > \lambda_v > \lambda_x$

(C) $\lambda_v > \lambda_x > \lambda_m$ (D) $\lambda_v > \lambda_m > \lambda_x$

Q.22 The velocity of electromagnetic radiation in a medium of permittivity ε_0 and permeability μ_0 is given by –

(A) $\sqrt{\frac{\mu_0}{\varepsilon_0}}$ (B) $\sqrt{\frac{\varepsilon_0}{\mu_0}}$

(C) $\sqrt{\mu_0 \varepsilon_0}$ (D) $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

Q.23 The electric field part of an electromagnetic wave in a medium is represented by $E_x = 0$;

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

$E_z = 0$. The wave is:

(A) moving along x direction with frequency 10^6 Hz and wave length 100 m.

(B) moving along x direction with frequency 10^6 Hz and wave length 200 m.

(C) moving along –x direction with frequency 10^6 Hz and wave length 200 m.

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

Q.24 An electromagnetic wave travels in a vacuum. The wavelength of the wave is tripled. How is this accomplished?

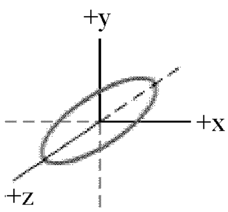
(A) By tripling the frequency of the wave.

(B) By tripling the speed of the wave.

(C) By reducing the frequency of the wave by a factor of three.

(D) By reducing the speed of the wave by a factor of three.

Q.25 The figure shows an x, y, z coordinate system. A circular loop of wire lies in the z, x plane and, when used with an LC tuned circuit, detects an electromagnetic wave. Which one of the following statements is correct?



(A) The wave travels along the x axis, and its electric field oscillates along the y axis.

(B) The wave travels along the z axis, and its electric field oscillates along the x axis.

(C) The wave travels along the z axis, and its electric field oscillates along the y axis.

(D) The wave travels along the y axis, and its electric field oscillates along the x axis.

Q.26 An electromagnetic wave is traveling in a vacuum. The electric field E of the wave is doubled. What happens to the magnetic field B, the total energy density u, and the intensity S of the wave?

(A) B doubles, u increases by a factor of four, S increases by a factor of four

(B) B doubles, u doubles, S doubles

(C) B increases by a factor of four, u increases by a factor of four, S increases by a factor of four

(D) B doubles, u increases by a factor of four, S doubles

Q.27 A point source of 2 watts is radiating uniformly in all direction in vaccum. Find the amplitude of electric field at a distance 2m from it-

(A) 3×10^{-4} (B) 3×10^{-2}

(C) $\sqrt{3} \times 10^{-4}$ (D) $\sqrt{3} \times 10^{-2}$

Q.28 A magnetic field in a plane electromagnetic wave is given by $B_y = 2 \times 10^{-7} \sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$ tesla. What is wavelength and frequency of the wave ?

(A) 23.9 Hz (B) 13.9 Hz

(C) 33.9 Hz (D) 12.9 Hz

Q.29 The electric field of a plane electromagnetic wave in vacuum is represented by $E_x = 0$, $E_y = 0.5 \cos[2\pi \times 10^8 (t - x/c)]$ and $E_z = 0$. Determine the wavelength of the wave.

(A) 4m (B) 5m

(C) 3m (D) 6m

Q.30 A light beam travelling in the X-direction is described by the electric field $E_y = (300 \text{ V/m})\sin\omega(t - x/c)$. An electron is constrained to move along the Y-direction with a speed of 2.0×10^7 m/s. Find the maximum magnetic force on the electron.

(A) 3.2×10^{-18} (B) 5.1×10^{-16}

(C) 6.5×10^{-11} (D) 7.8×10^{-12}

Q.31 The TV transmission tower at a particular staion has a height of 160 m. What is its coverage range ?

(A) 15255 m (B) 45255 m

(C) 25125 m (D) 61232 m

Q.32 In the above question, how much population is covered by transmission, if the average population density around the tower is $1200/\text{km}^2$.

(A) 77.29 lakh (B) 62.29 lakh

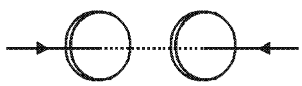
(C) 71.12 lakh (D) 63.34 lakh

Q.33 By how much the height of tower be increased to double its coverage range ?

(A) 320m (B) 180m

(C) 480m (D) 512m

Q.34 Fig. shows a capacitor made of two circular plates each of radius 12 cm and separated by 5.0 mm. The capacitor is being charged by an external source (not shown in the figure). The charging current is constant and equal to 0.15A.



Calculate the rate of change of potential difference between the plates.

Given $\in_0 = 8.85 \times 10^{-12}\ C^2N^{-1}\ m^{-2}$

(A) $4.32 \times 10^4\ Vs^{-1}$ (B) $3.17 \times 10^9\ Vs^{-1}$

(C) $5.34 \times 10^8\ Vs^{-1}$ (D) $1.87 \times 10^9\ Vs^{-1}$

Q.35 In which one of the following regions of the electromagnetic spectrum will the vibrational motion of molecules give rise to absorption

(A) Ultraviolet (B) Microwaves

(C) Infrared (D) Radio waves

Q.36 Electromagnetic radiation of highest frequency is –

(A) Infrared radiations (B) Visible radiation

(C) Radio waves (D) γ-rays

For Q.37-Q.41

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

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

Q.37 What is the direction of propagation?

(A) negative y direction (B) positive y direction

(C) negative x direction (D) positive x direction

Q.38 What is the wavelength λ?

(A) 7 m (B) 3.5 m

(C) 5 m (D) 6m

Q.39 What is the frequency ν?

(A) 43 MHz (B) 33 MHz

(C) 98 MHz (D) 86 MHz

Q.40 What is the amplitude of the magnetic field part of the wave?

(A) 10 nT (B) 5 nT

(C) 4 nT (D) 3 nT

Q.41 An expression for the magnetic field part of the wave is –

(A) $10nT\ (\cos 1.8y\ rad\ m^{-1} + 5.4\times10^6 rad\ s^{-1})\ \hat{j}$

(B) $5nT\ (\cos 1.8y\ rad\ m^{-1} + 5.4\times 10^6\ rad\ s^{-1})\ \hat{k}$

(C) $10nT\ (\cos 1.8y\ rad\ m^{-1} + 5.4\times10^6\ rads^{-1})\ \hat{k}$

(D) $10nT\ (\cos 1.8y\ rad\ m^{-1} + 5.4\times10^3 rad\ s^{-1})\ \hat{k}$

For Q.42-Q.45

Given below are some famous numbers associated with electromagnetic radiations in different contexts in physics. State the part of the electromagnetic spectrum to which each belongs.

Q.42 21 cm (wavelength emitted by atomic hydrogen in interstellar space).

(A) short radio wave. (B) micro wave.

(C) visible radiation (D) X-ray

Q.43 2.7 K [temperature associated with the isotropic radiation filling all space-thought to be a relic of the 'big-bang' origin of the universe].

(A) short radio wave. (B) micro wave.

(C) visible radiation (D) X-ray

Q.44 5890 Å - 5896 Å [double lines of sodium]

(A) short radio wave. (B) micro wave.

(C) visible radiation (D) X-ray

Q.45 14.4 keV [energy of a particular transition in ^{57}Fe nucleus associated with a famous high resolution spectroscopic method (Mossbauer spectroscopy)].

(A) short radio wave. (B) micro wave.

(C) visible radiation (D) X-ray