PRACHAND NEET

ONE SHOT

PHYSICS

Electromagnetic (EM) Waves

TANUJ BANSAL SIR (TBS)

Topics *to be covered*

1. Displacement Current
2. Maxwell's Equations
3. Equation of EM Wave, Energy Density
4. Electromagnetic Spectrum

चलिए शुरू करते हैं


TBS Army – Tanuj Sir
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Physics Wallah


PRACHAND SERIES
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Weightage and Analysis

- 1-2 Ques Average , 2024 → 1
- Easy and scoring chapter
- Lesser time consuming (Theory Based)

Introduction

Electromagnetic waves are 'Light waves'

These are non mechanical waves, which do not require the medium to travel.

* $c = 3 \times 10^8$ m/s (vacuum)

History

1. Maxwell: Told about the existence of EM waves.
2. Hertz: Production of EM waves for the first time.
3. J.C.Bose: EM waves of shorter wavelength produced.
4. Marconi: Transmitted EM waves from one place to another via antenna.

Main Concept

The changing magnetic flux (field) produces electric field.

Since nature is symmetric, so, changing electric flux (field) must produce magnetic field.

* Faraday's Law

$$\oint \vec{E} \cdot \vec{dl} = e = \frac{-d\phi_B}{dt}$$

↓ induced electric field

B change → E produced

E change → B produced

Both E & B are variable

⇓

EM Waves

* Electrostatics

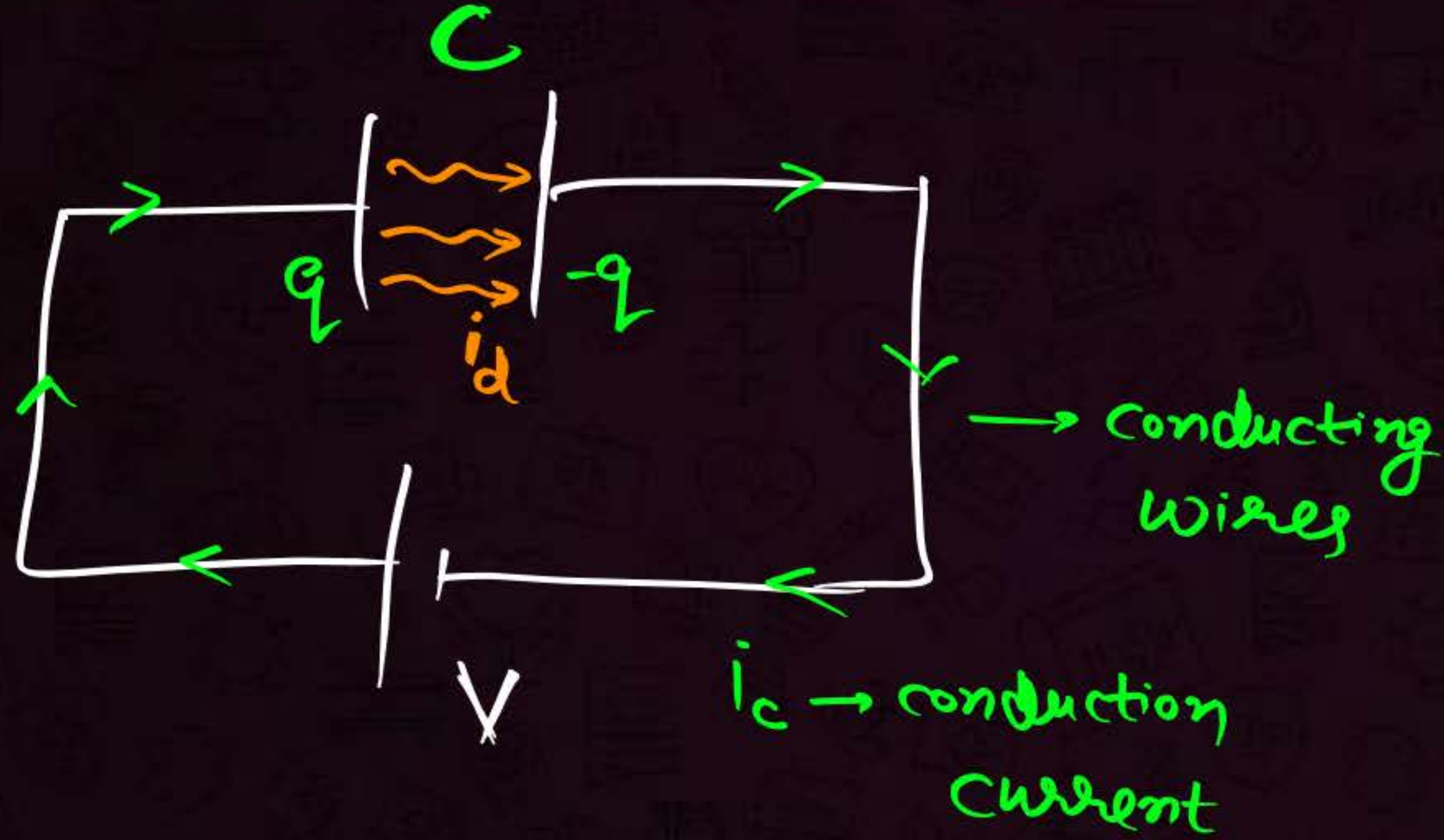
$$dV = -\vec{E} \cdot \vec{dr}$$

↓

$$e = \vec{E} \cdot \vec{dl}$$

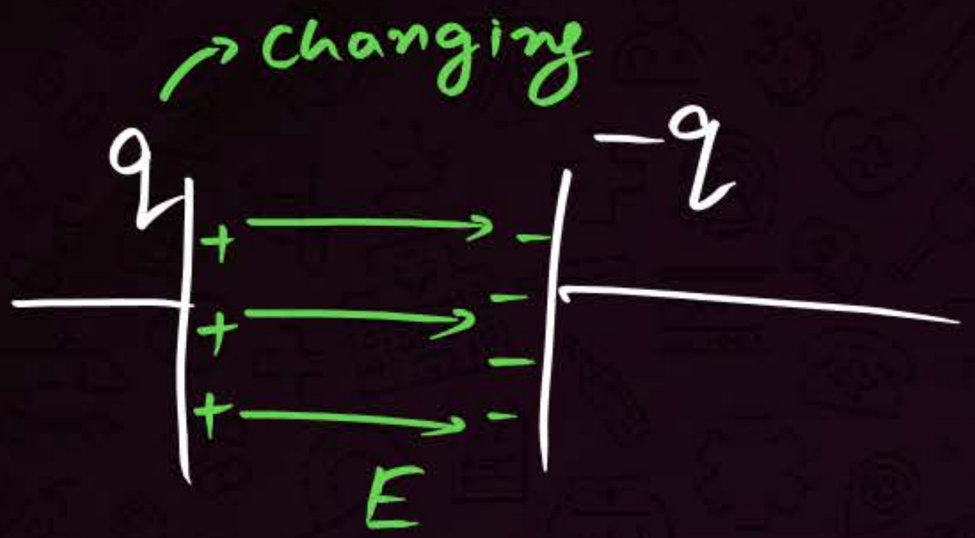
Displacement Current

→ i_d → inside capacitor



* Continuity of current

$$i_d = i_c$$



$$E = \frac{\sigma}{\epsilon_0} = \frac{q}{A\epsilon_0}$$

$$EA = \frac{q}{\epsilon_0} = \phi_E$$

$$q = \epsilon_0 \phi_E$$

q ↓ changing, ϕ_E ↓ changing

$$q = \epsilon_0 \, d\phi_E$$

$$i_d = \frac{dq}{dt} = \epsilon_0 \frac{d\phi_E}{dt}$$

i_d → B

ϕ_E → change → i_d produced

→ B produced

* $$i_d = \epsilon_0 \frac{d(EA)}{dt} = \epsilon_0 A \frac{dE}{dt}$$

$$i_d = \frac{dq}{dt} = \frac{d(CV)}{dt} = C\frac{dV}{dt}$$

$$* \quad i_d = \frac{dq}{dt} = C\frac{dV}{dt} = \epsilon_0 \frac{d\phi_E}{dt} = \epsilon_0 A \frac{dE}{dt} \Rightarrow i_C$$

Ampere – Maxwell Law

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 i_{encl}$$

↓

Poora Sahi Nhi Hai

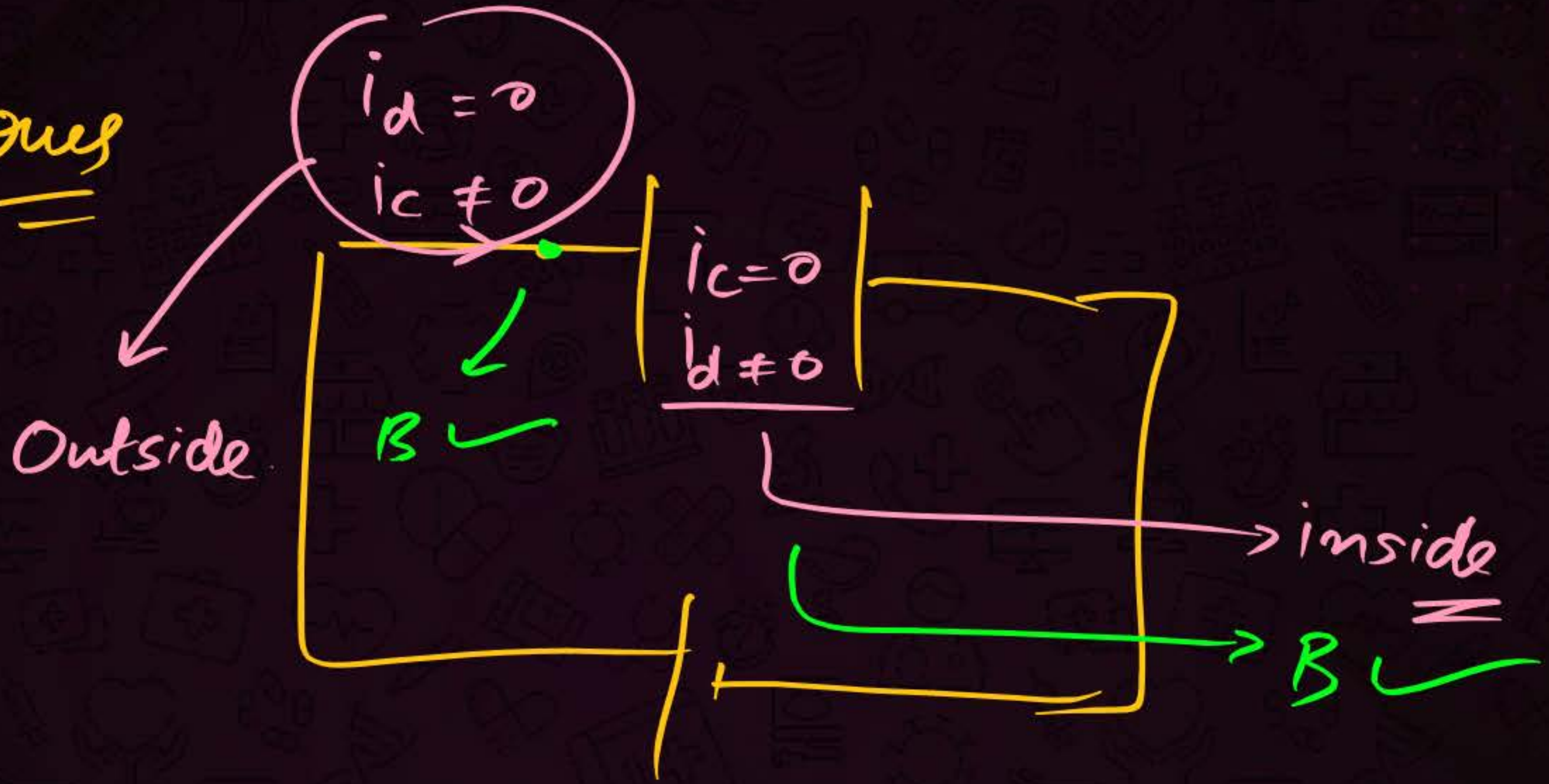
$$\oint \vec{B} \cdot \vec{dl} = \mu_0 (i_c + i_d)$$

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 \left(i_c + \epsilon_0 \frac{d\phi_E}{dt}\right)$$

↓

Modified Ampere's Law

Ques



QUESTION

Assertion: A changing electric field produces a magnetic field.

Reason: A changing magnetic field produces an electric field.

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)
2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)
3. Assertion (A) is True, Reason (R) is False.
4. Assertion (A) is False, Reason (R) is True.

QUESTION

In order to establish an instantaneous displacement current of 1 mA in the space between the plates of $2\mu F$ parallel plate capacitor, the rate of potential difference to be needed to apply is

(1) $100\ Vs^{-1}$

(2) $200\ Vs^{-1}$

(3) $300\ Vs^{-1}$

(4) $500\ Vs^{-1}$

$$i_d = C\frac{dV}{dt}$$

$\rightarrow \frac{dV}{dt}$

$$10^{-3} = 2\times10^{-6}\times\frac{dV}{dt}$$

$$\frac{10^3}{2} = \frac{dV}{dt} = 500$$

QUESTION

The charge of a parallel plate capacitor is varying as $q = q_0 \sin 2\pi \upsilon t$. The plates are very large and close together. Neglecting edge effects, the displacement current through the capacitor is

[AIIMS 2018]

1. $\frac{q}{A\varepsilon_0}$
2. $\frac{q}{\varepsilon_0} \sin 2\pi \upsilon t$
3. $2\pi \upsilon q_0 \cos 2\pi \upsilon t$ (77%)
4. $\frac{2\pi \upsilon q_0}{\varepsilon_0} \cos 2\pi \upsilon t$

$$i_d = \frac{dq}{dt} = q_0 \times \cos 2\pi\upsilon t \times (2\pi\upsilon \times 1)$$

$$= q_0 2\pi\upsilon \cos 2\pi\upsilon t$$

$$2\pi\upsilon = \omega$$

QUESTION

AC voltage $V(t) = 20 \sin \omega t$ of frequency 50 Hz is applied to a parallel plate capacitor. The separation between the plates is 2 mm and the area is 1 m^2. The amplitude of the oscillating displacement current for the applied AC voltage is ______.

[Take $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m]

2×10^{-3} m

[20 July, 2021 (Shift-I)]

(JEE Mains)

(1) 83.37 μA

(2) 55.58 μA

(3) 21.14 μA

(4) 27.79 μA ✓

$V = 20 \sin \omega t$

$i = C \frac{dV}{dt} = C \times 20 \times \omega \cos \omega t$

$i = C \times 20 \times 2\pi f \times \cos \omega t$

$\downarrow$

i_0

$i_0 = \frac{A\varepsilon_0}{d} \times 20 \times 2\pi f$

$= \frac{1 \times 8.85 \times 10^{-12}}{2 \times 10^{-3}} \times 20 \times 2\pi \times 50$

$= 8.85 \times 10^{-9} \times 1000\pi$

$= 8.85\pi \times 10^{-6}$

$= 8.85 \times 3.14 \times 10^{-6}$

$9 \times 3 \times 10^{-6}$

$= 27 \mu A$

QUESTION

A 100 Ω resistance and a capacitor of 100 Ω reactance are connected in series across a 220V source. When the capacitor is 50% charged, the peak value of the displacement current is: **[2016 – II]**

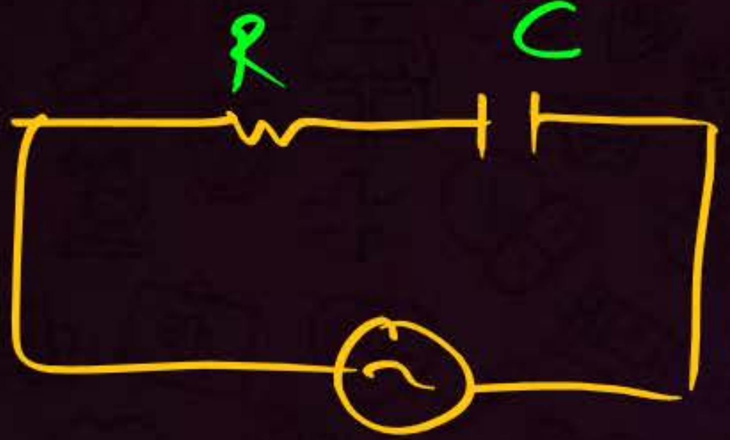
(1) 4.4 A

(2) $11\sqrt{2}$ A

(3) 2.2 A

(4) 11 A

→ No use

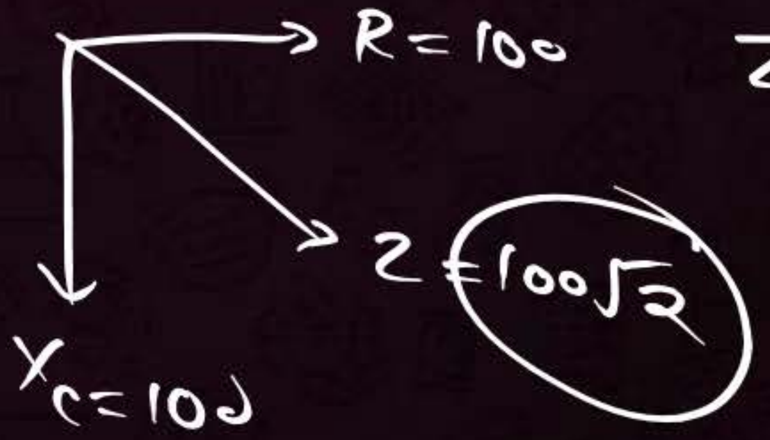


$V_{rms} = 220\,V$

$V_0 = 220\sqrt{2}$

$i_0 = \frac{V_0}{Z} = \frac{220\sqrt{2}}{100\sqrt{2}} = 2.2\,A$

$Z = \sqrt{X_C^2 + R^2}$



$Z = \sqrt{(X_L - X_C)^2 + R^2}$

QUESTION

A parallel plate capacitor of capacitance 20μF 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. 60 μA, 60 μA
2. 60 μA, zero (unequal)
3. zero, zero
4. zero, 60 μA (unequal)

$$i_d = \frac{C\,dV}{dt} = 20 \times 3 = 60\ \mu A$$

Maxwell's Equations

① $\oint \vec{E} \cdot d\vec{S} = \frac{q_{enc}}{\epsilon_0}$

Gauss Law

* coulomb's law can be derived from it.

② $\oint \vec{B} \cdot d\vec{S} = 0$

Magnetic monopoles do not exist.

Gauss Law in Magnetism.

③ $\oint \vec{E} \cdot d\vec{l} = e = -\frac{d\phi_B}{dt}$

Faraday's Law

④ $\oint \vec{B} \cdot d\vec{l} = \mu_0 \left(i_c + \epsilon_0 \frac{d\phi_E}{dt} \right)$

Ampere-Maxwell law.

Four eqⁿs of maxwell eqn's

+

Lorrentz Force eqn $\vec{F} = \vec{F_e} + \vec{F_b}$

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

= Whole electromagnetism

QUESTION

Match List-I with List-II:

Choose the correct answer from the options given below: **[25 Jan 2023 (Shift-II)]**

A.	Gauss's Law in Electrostatics	I.	$\oint \vec{E} \cdot \vec{dl} = -\frac{d\phi_B}{dt}$
B.	Faraday's Law	II.	$\oint \vec{B} \cdot d\vec{A} = 0$
C.	Gauss's Law in Magnetism	III.	$\oint \vec{B} \cdot \vec{l} = \mu_0 i_C + \mu_0 \epsilon_0 \frac{d\phi_E}{dt}$
D.	Ampere Maxwell Law	IV.	$\oint \vec{E} \cdot \vec{s} = \frac{q}{\epsilon_0}$

(1) A-IV, B-I, C-II, D-III

(2) A-I, B-II, C-III, D-IV

(3) A-III, B-IV, C-I, D-II

(4) A-II, B-III, C-IV, D-I

Source of EM Waves

A stationary charge produces Electric Field only.

$(\vec{E})$

$(\vec{E})$ $(\vec{B})$

A charge moving with constant velocity produces Electric and Magnetic Field both.

An accelerating charge produces Electric Field and Magnetic field both, both are variable and produce each other and hence EM Waves are produced.

eg :- oscillating charge

eg :- Radio waves produced.

QUESTION

Assertion: When a charged particle moves in a circular path. It produces electromagnetic wave.

Reason: Charged particle has acceleration. [AIIMS 2016]

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)
2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)
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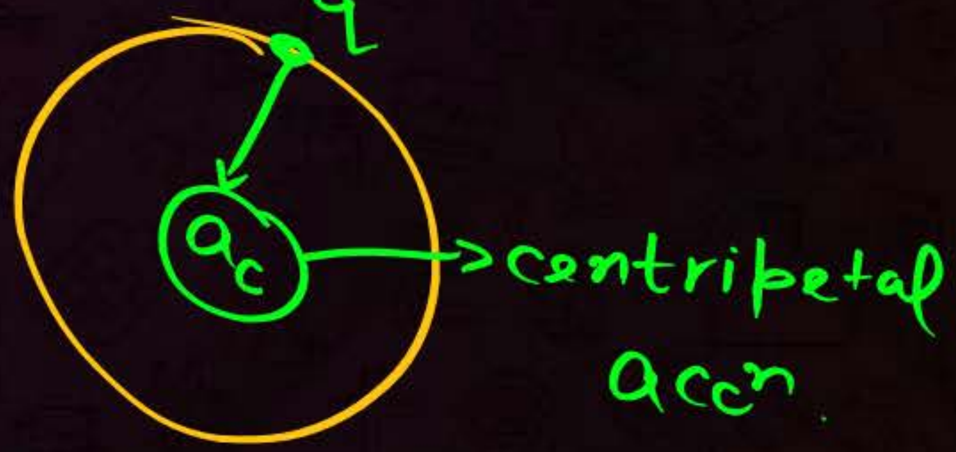

QUESTION

Assertion: Dipole oscillations produces electromagnetic waves.

Reason: Accelerated charge produces electromagnetic waves. [AIIMS 2007]

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)
2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)
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Basics of Wave Motion → 11th Class

* $y = A\sin(\omega t - kx) \Rightarrow$ wave propagation in $+x$

$y = A\sin(\omega t + kx) \Rightarrow$ " " " $-x$.

$\omega = 2\pi f$

$k = \frac{2\pi}{\lambda}$

v = speed of wave.

$v = f\lambda = \frac{\lambda}{T} = \frac{\omega}{k}$

Equation of EM Waves

EM Waves contain oscillating Electric and Magnetic Field vectors. → variable

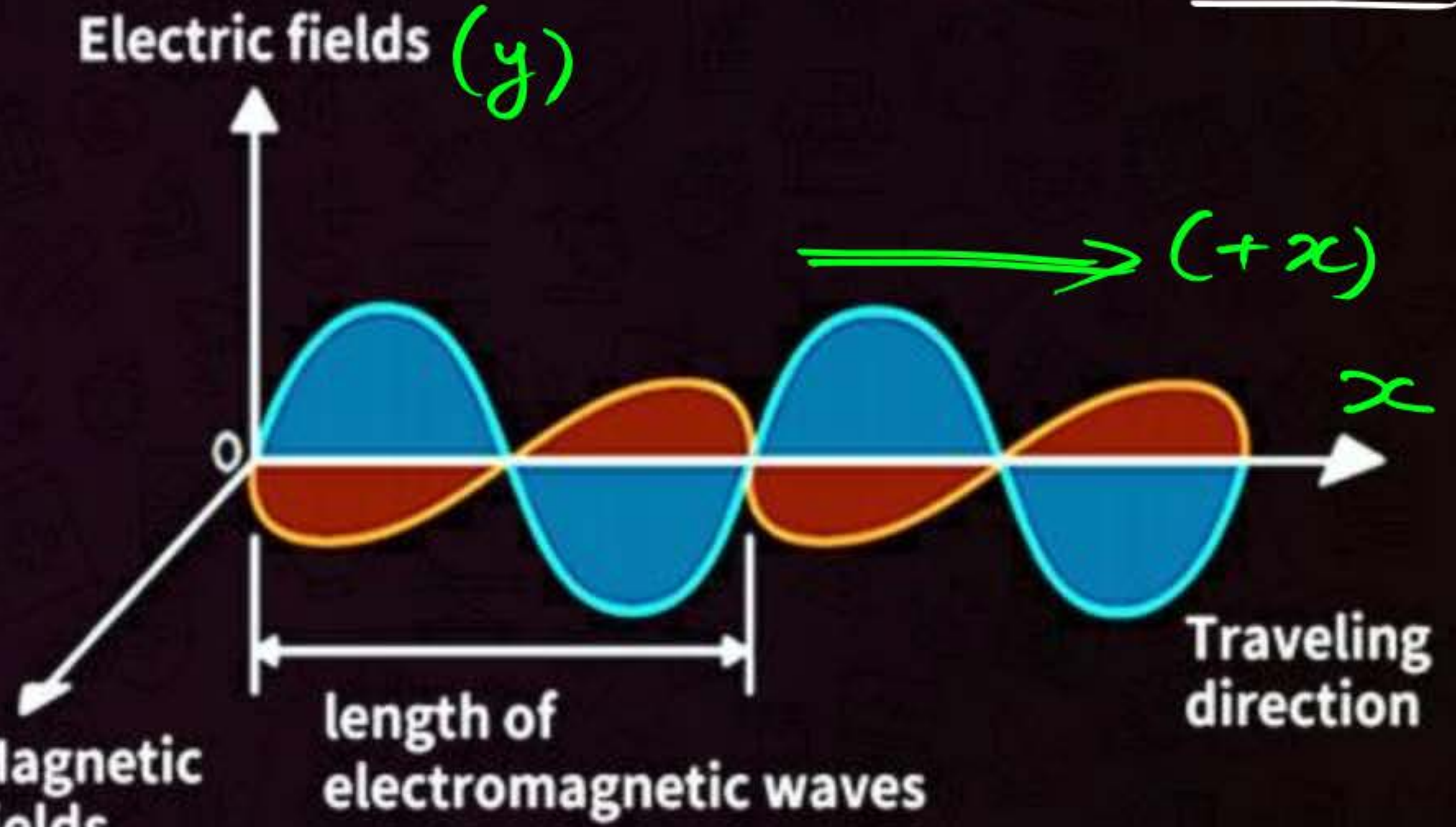
$$E_y = E_0 \sin(\omega t - kx)$$

$$B_z = B_0 \sin(\omega t - kx)$$

vacuum (free space)

* $E_0 = cB_0$ (England, cricket, Board)
* $E_{av} = cB_{av}$
* $E_{rms} = cB_{rms}$

E_0, B_0 ⇓ Maxm/peak amplitudes of E & B



$\vec{E}, \vec{B}, \vec{v}$ ↳ mutually ⊥ular

QUESTION

The average electric field of electromagnetic waves in certain region of free space is $9 \times 10^{-4}\ NC^{-1}$. Then the average magnetic field in the same region is of the order of

1. 27×10^{-4} T
2. 3×10^{-12} T
3. $\left(\frac{1}{2}\right) \times 10^{-12}$ T
4. 3×10^{12} T

$$E = cB$$

$$B = \frac{E}{c} = \frac{9 \times 10^{-4}}{3 \times 10^{8}}$$

$$= 3 \times 10^{-12}.$$

QUESTION

In a plane electromagnetic wave travelling in free space, the electric field component oscillates sinusoidally at a frequency of 2.0×10^{10} Hz and amplitude $48\ Vm^{-1}$. Then the amplitude of oscillating magnetic field is:

(Speed of light in free space = $3 \times 10^8\ ms^{-1}$) **[2023]**

(1) 1.6×10^{-6} T

(2) 1.6×10^{-9} T

(3) 1.6×10^{-8} T

(4) 1.6×10^{-7} T

$$B = \frac{E}{C} = \frac{48}{3 \times 10^8}$$

$= 16 \times 10^{-8}$

$= 1.6 \times 10^{-7}$

16×10^{-8}

$= 16 \times 10^{-1} \times 10^{-7}$

$= \frac{16}{10} \times 10^{-7}$

$= 1.6 \times 10^{-7}$

16×10^{-8}

$1.6 \times 10^{-8+1} = 1.6 \times 10^{-7}$

←

$0.16 \times 10^{-7+1} \Rightarrow 0.16 \times 10^{-6}$

←

$0.016 \times 10^{-6+1} \Rightarrow 0.016 \times 10^{-5}$

TBS

← Decimal

10^{n+1}

→ Decimal

10^{n-1}

QUESTION

A plane electromagnetic wave with frequency of 30 MHz travels in free space. At particular point in space and time, electric field is 6 V/m. The magnetic field at this point will be $x \times 10^{-8}$ T. The value of x is 2.

[27 Aug, 2021 (Shift-II)]

$$B = \frac{E}{c} = \frac{6}{3 \times 10^{-8}}$$

$$= 2 \times 10^{-8}$$

QUESTION

Light wave travelling in air along x-direction is given by
$E_y = 540 \sin \pi \times 10^4 (x - ct) \text{Vm}^{-1}$.
Then, the peak value of magnetic field of wave will be: (Given, $c = 3 \times 10^8 \text{ ms}^{-1}$)

[26 July, 2022 (Shift-II)]

(1) $18 \times 10^{-7}\ T$

(2) $54 \times 10^{-7}\ T$

(3) $54 \times 10^{-8}\ T$

(4) $18 \times 10^{-8}\ T$

$E_0 = 540$

$\frac{540}{3 \times 10^8} = \frac{180}{10^8} = \frac{18}{10^7}$

$= 18 \times 10^{-7}$

QUESTION

Electric field in a plane electromagnetic wave is given by

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

The velocity of electromagnetic wave in this medium is: (Given c = speed of light in vacuum)

[27 Aug, 2021 (Shift-I)]

(1) c

(2) $\frac{c}{2}$

(3) $\frac{2}{3}c$

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

vacuum ×

$v = \frac{\omega}{k} = \frac{10 \times 10^{10}}{500} = 2 \times 10^{8}$

$y = A\sin(\omega t - kx)$

$v = 2 \times 10^{8}$

$\frac{v}{c} = \frac{2 \times 10^{8}}{3 \times 10^{8}}$

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

QUESTION

The oscillating magnetic field in a plane electromagnetic wave is given by $B_y = 5 \times 10^{-6} \sin 100\pi (5x - 4 \times 10^8 t) T$. The amplitude of electric field will be:

B_0

[26 July, 2022 (Shift-II)]

(1) $15 \times 10^2 \, Vm^{-1}$

(2) $5 \times 10^{-6} \, Vm^{-1}$

(3) $16 \times 10^{12} \, Vm^{-1}$

(4) $4 \times 10^2 \, Vm^{-1}$ ✓

$v = \frac{4 \times 10^8}{5}$

$= \frac{4 \times 10^7 \times 10}{5}$

$v = 8 \times 10^7$

Vacuum ✗

$E = cB$ ✗

$E = vB$

$E = 8 \times 10^7 \times 5 \times 10^{-6}$

$= 40 \times 10 = 4 \times 10^2$

QUESTION

The electric field and magnetic field components of an electromagnetic wave going through vacuum is described by

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

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

Then the correct relation between E_0 and B_0 is given by [24 Jan, 2023 (Shift-II)]

1. $kE_0 = \omega B_0$
2. $E_0 B_0 = \omega k$
3. $\omega E_0 = kB_0$
4. $E_0 = kB_0$

$E_0 = cB_0$

$E_0 = \frac{\omega}{k} B_0$

$E_0 k = \omega B_0$

QUESTION

H/W

The magnetic field in a plane electromagnetic wave is given by
$B_y = 2 \times 10^{-7} \sin(\pi \times 10^3 x + 3\pi \times 10^{11} t)$
Calculate the wavelength. [NEET (Oct.) 2020]

(1) $\pi \times 10^3$ m

(2) 2×10^{-3} m ✓

(3) 2×10^3 m

(4) $\pi \times 10^{-5}$ m

QUESTION

H.W

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

(1) $2\ m^{-1}$

(2) $0.5\ m^{-1}$

(3) $6\ m^{-1}$

(4) $3\ m^{-1}$

QUESTION

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

$E_x = 0; E_y = 2.5 \frac{N}{C} \cos\left[\left(2\pi \times 10^6 \frac{rad}{s}\right)t - \left(\pi \times 10^{-2} \frac{rad}{m}\right)x\right]$ [2009]

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 800m

ω k

$\frac{2\pi}{\lambda} = \pi \times 10^{-2}$

$2 \times 10^2 = \lambda$

$200 = \lambda$

Not check

Properties of EM Waves

(1) In these waves $\vec{E}$ and $\vec{B}$ vary sinusoidally. $\vec{E}$ and $\vec{B}$ become maximum at same place and at the same time. Therefore the phase difference between the two fields is zero.

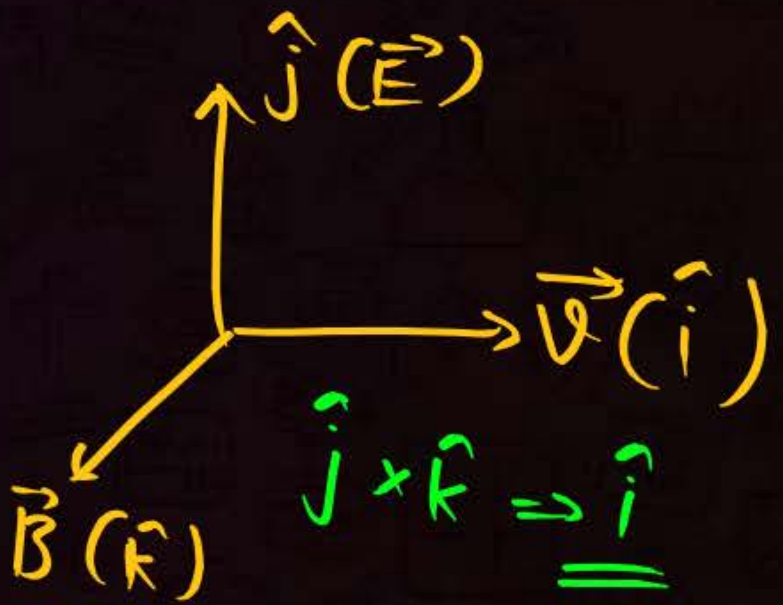
→ same phase. → $\Delta\phi = 0$

$\sin(\omega t - kx)$

(2) $\vec{E}$ and $\vec{B}$ are perpendicular to each other as well as to direction of propagation ($\vec{v}$).

The direction of propagation can be determined by $\vec{E} \times \vec{B}$

$$\vec{v} \parallel \vec{E} \times \vec{B}$$



(3) These waves do not require material medium for their propagation.

(4) It travels in free space with speed equal to 3×10^8 m/s which is given by $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$. (vacuum)

(5) The speed of electromagnetic wave in a medium is $v = \frac{1}{\sqrt{\mu \varepsilon}}$

$$n = \text{Refractive} = \frac{c}{v} = \frac{\frac{1}{\sqrt{\mu_0 \epsilon_0}}}{\frac{1}{\sqrt{\mu \epsilon}}} = \frac{\sqrt{\mu \epsilon}}{\sqrt{\mu_0 \epsilon_0}} = \sqrt{\mu_r \epsilon_r}.$$

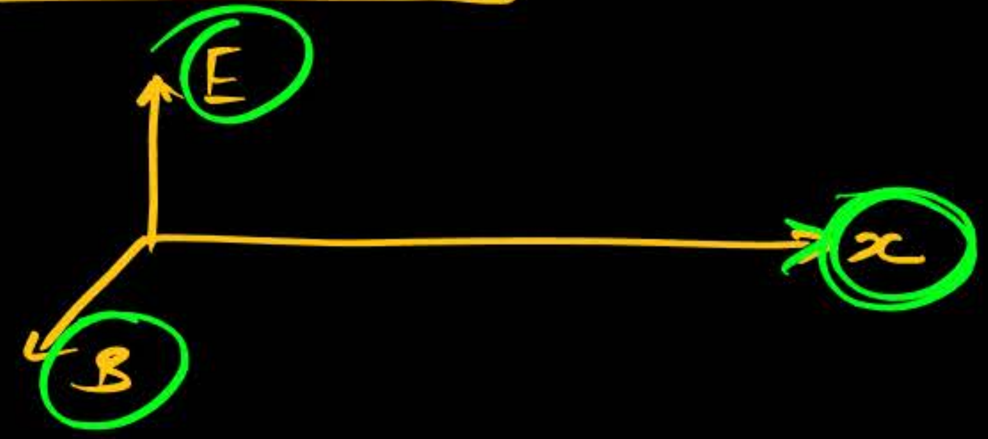
$$n = \sqrt{\mu_r \epsilon_r}.$$

μ_r → permeability

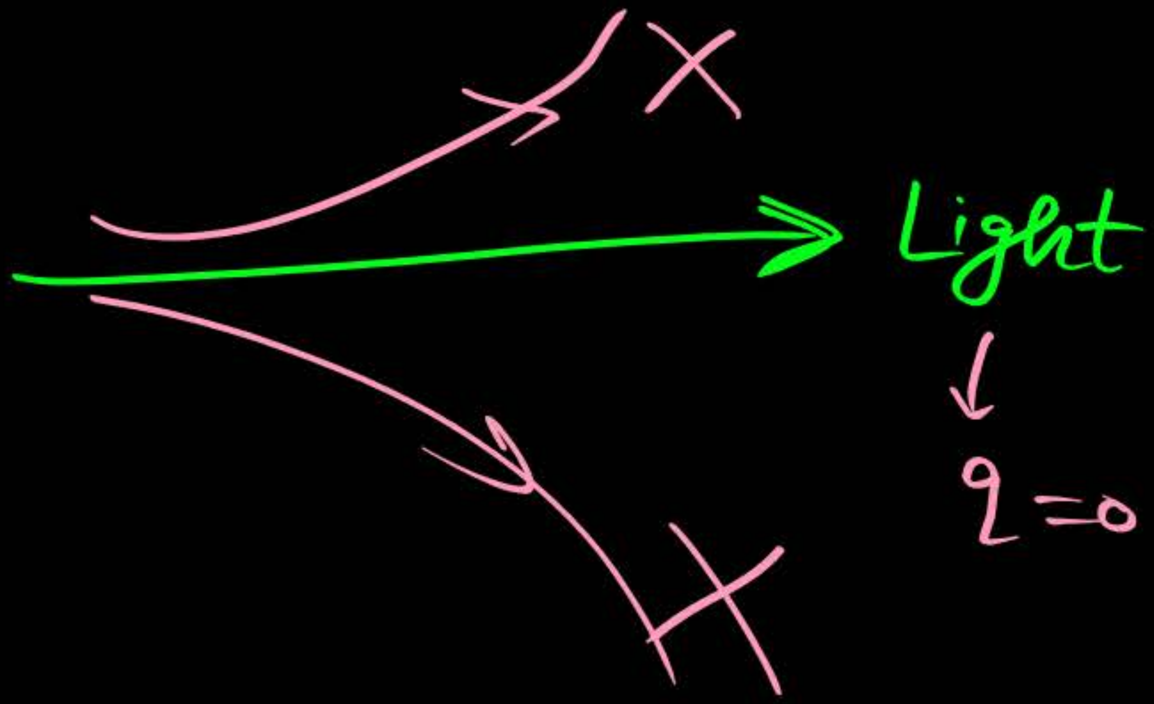
ϵ_r → relative permittivity (dielectric const.)

(6) Electric field vector of an electromagnetic wave produces optical effect hence it is also known as light/optical vector.

(7) EM waves can be polarized (transverse waves)



(8) They cannot be deflected by electric and magnetic fields



$$\vec{F_e} = q\vec{E} = 0$$

$$\vec{F_b} = q(\vec{v} \times \vec{B}) = 0$$

QUESTION

Assertion: Electromagnetic waves are transverse in nature.

Reason: The electric and magnetic fields of an e.m. wave are perpendicular to each other and also perpendicular to the direction of waves propagation. [AIIMS 2010]

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)
2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)
3. Assertion (A) is True, Reason (R) is False.
4. Assertion (A) is False, Reason (R) is True.

QUESTION

Assertion: In electromagnetic waves electric field and magnetic field lines are perpendicular to each other.

Reason: Electric field and magnetic field are self sustaining. [AIIMS 2012]

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)
2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)
3. Assertion (A) is True, Reason (R) is False.
4. Assertion (A) is False, Reason (R) is True.

QUESTION

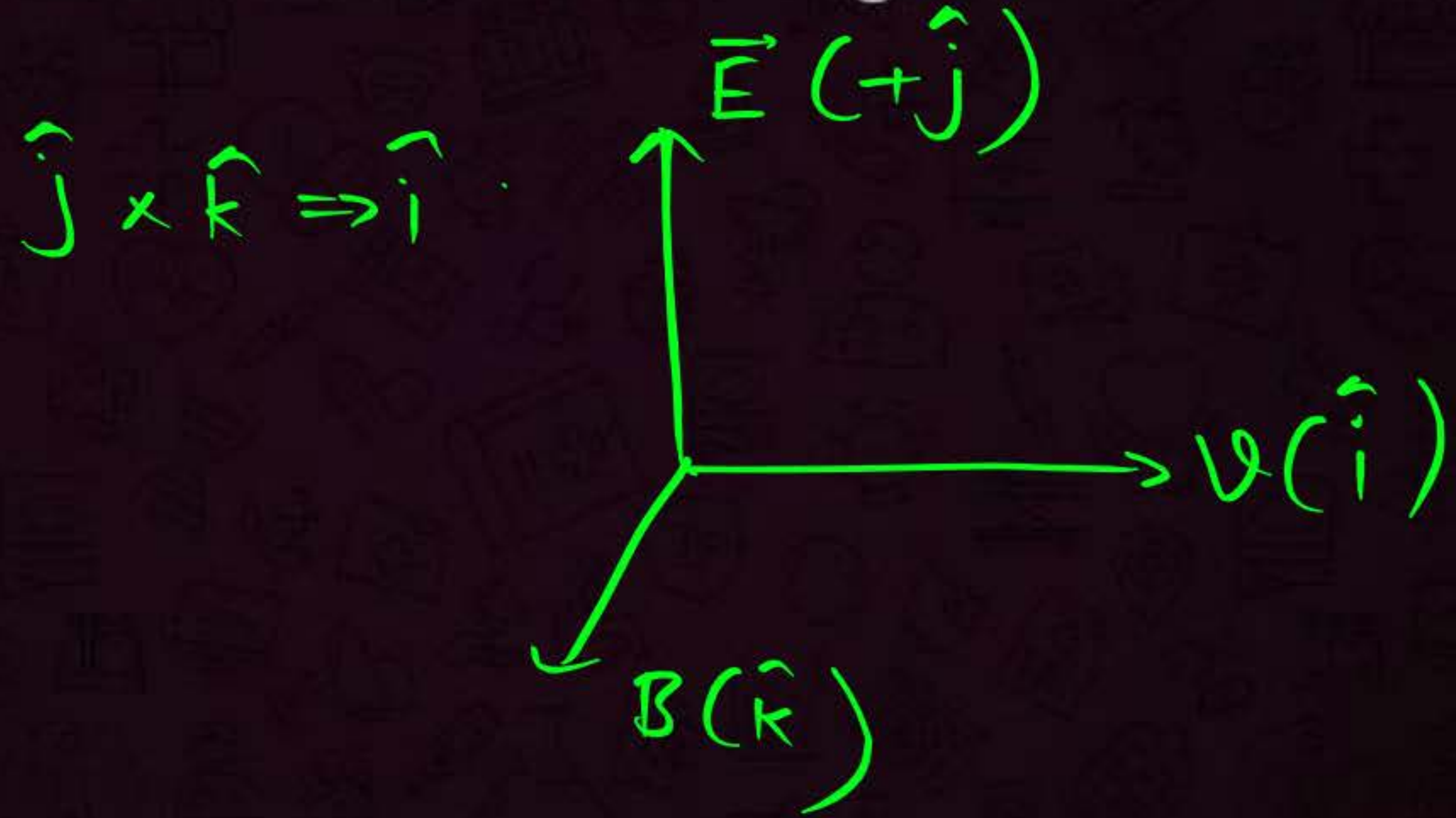
A plane electromagnetic wave propagating along y-direction, can have the following pair of electric field ($\vec{E}$) and magnetic field ($\vec{B}$) components: **[18 March, 2021 (Shift-II)]**

1. E_y, B_y or E_z, B_z
2. E_y, B_x or E_x, B_y
3. E_x, B_z or E_z, B_x
4. E_x, B_y or E_y, B_x

QUESTION

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



QUESTION

All electromagnetic wave is transporting energy in the negative z direction. At a certain point and certain time the direction of electric field of the wave is along positive y direction. What will be the direction of the magnetic field of the wave at that point and at that instant?

[25 Jan, 2023 (Shift-I)]

1. Positive direction of x
2. Positive direction of z
3. Negative direction of x
4. Negative direction of y

QUESTION

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

[20 July, 2021 (Shift-II)]

$\hat{i} \times \hat{k} \Rightarrow -\hat{j}$

1. $(-\hat{k})$
2. $(\hat{k})$
3. $(-\hat{j})$
4. $\hat{j}$

QUESTION

For a plane electromagnetic wave propagating in x-direction, which one of the following combination gives the correct possible directions for electric field (E) and magnetic field (B) respectively? **[2021]**

(1) $-\hat{j}+\hat{k}, -\hat{j}-\hat{k}$

(2) $\hat{j}+\hat{k}, -\hat{j}-\hat{k}$

(3) $-\hat{j}+\hat{k}, -\hat{j}+\hat{k}$

(4) $\hat{j}+\hat{k}, \hat{j}+\hat{k}$

$-\hat{j}+\hat{k}$, $-\hat{j}-\hat{k}$ $\vec{E}\cdot\vec{B}=0$

$(-\hat{j}+\hat{k})\times(-\hat{j}-\hat{k})$ = No need

QUESTION

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

[2 Sep, 2020 (Shift-II)]

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

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

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

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

$$\vec{E} \times \vec{B} \Rightarrow \hat{k} \times 2(\hat{i} - \hat{j})$$

$$\Rightarrow \hat{k} \times \hat{i} - \hat{k} \times \hat{j}$$

$$\Rightarrow \hat{j} - (-\hat{i})$$

$$\Rightarrow \hat{j} + \hat{i}$$

$$\frac{\hat{i} + \hat{j}}{\sqrt{2}} = \frac{\hat{i} + \hat{j}}{\sqrt{1^2 + 1^2}}$$

QUESTION

The magnetic field of a plane electromagnetic wave is

$\vec{B} = 3 \times 10^{-8} \sin[200\pi(y + ct)]\hat{i}T$

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

The corresponding electric field is

[03 Sep, 2020 (Shift-I)]

1. $\vec{E} = 9 \sin[200\pi(y + ct)]\hat{k}V/m$
2. $\vec{E} = -9 \sin[200\pi(y + ct)]\hat{k}V/m$
3. $\vec{E} = 3 \times 10^{-8} \sin[200\pi(y + ct)]\hat{k}V/m$
4. $\vec{E} = -10^{-6} \sin[200\pi(y + ct)]\hat{k}V/m$

QUESTION

HW

Match the Column-I and Column-II.

(1) A-(r); B-(s); C-(r); D-(q)

(2) A-(p); B-(q); C-(s); D-(r)

(3) A-(q); B-(p); C-(r); D-(s)

(4) A-(r); B-(s); C-(q); D-(p)

Column-I Relative Permeabilities & permittivity's of the medium		Column-II Refractive index of the medium	
A.	$\vec{E} // \hat{\imath}, \vec{B} // \hat{\jmath}$	p.	$-\hat{\jmath}$
B.	$\vec{E} // (\hat{\imath} + \hat{\jmath}), \vec{B} // (\hat{\imath} - \hat{\jmath})$	q.	$\hat{\jmath}$
C.	$\vec{E} // (-\hat{\jmath}), \vec{B} // (\hat{\imath})$	r.	$\hat{k}$
D.	$\vec{E} // (\hat{k} - \hat{\imath}), \hat{B} // (\hat{k} + \hat{\imath})$	s.	$-\hat{k}$

QUESTION

If $\vec{E}$ and $\vec{K}$ represent electric field and propagation vectors of the EM waves in vacuum, then magnetic field vector is given by: (ω - angular frequency):

[24 Jan, 2023 (Shift-I)]

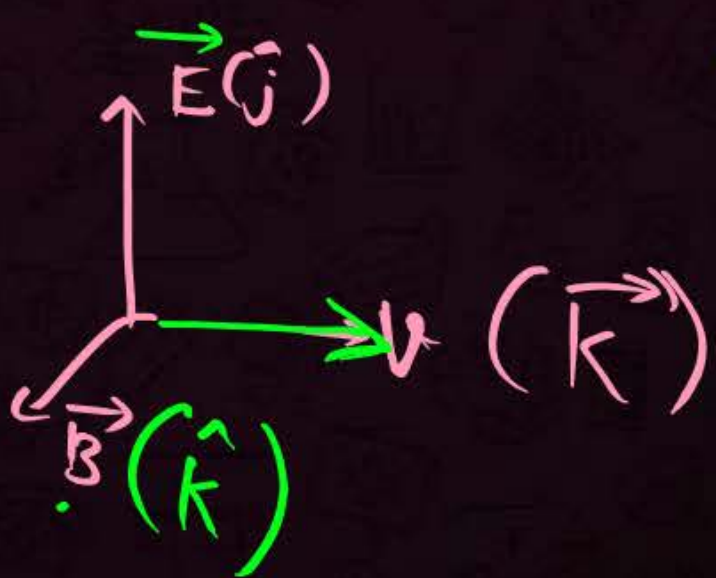
1. $\frac{1}{\omega}(\vec{K} \times \vec{E})$
2. $\omega(\vec{E} \times \vec{K})$
3. $\omega(\vec{K} \times \vec{E})$
4. $\vec{K} \times \vec{E}$

$\vec{v} \rightarrow \vec{K}$

$\vec{E}$

$\vec{B} \Rightarrow ?$

$\vec{K} \times \vec{E}$ → Thumb out $(\hat{k})$



$E = cB$

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

$B = \frac{E}{\omega / k} = \frac{Ek}{\omega}$

QUESTION

An electromagnetic wave of frequency 5 GHz, is travelling in a medium whose relative electric permittivity and relative magnetic permeability both are 2. Its velocity in the this medium is ___15___ $\times 10^7$ m/s

[24 Feb. 2021 (Shift-I)]

$\mu_r = 2$

$\epsilon_r = 2$

$n = \sqrt{\mu_r \epsilon_r} = \sqrt{2 \times 2} = 2.$

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

$v = \frac{c}{n} = \frac{c}{2} = \frac{3 \times 10^8}{2} = \frac{3 \times 10}{2} \times 10^7$

$= 15 \times 10^7$

QUESTION

Match the Column-I and Column-II.

1. A-(p); B-(p); C-(s); D-(r)
2. A-(p); B-(q); C-(p); D-(r)
3. A-(q); B-(q); C-(p); D-(r)
4. A-(q); B-(q); C-(s); D-(r)

Column-I Relative Permeabilities & permittivity's of the medium		Column-II Refractive index of the medium	
A.	$\varepsilon_r = 1, \mu_r = 2$	p.	$n = 2$
B.	$\varepsilon_r = 2, \mu_r = 1$	q.	$n = \sqrt{2}$
C.	$\varepsilon_r = 2, \mu_r = 2$	r.	$n = \sqrt{3}$
D.	$\varepsilon_r = 1, \mu_r = 3$	s.	$n = 4$

QUESTION

Statement-I: The properties of a medium is given by $\mu_r = 0.5$, $\varepsilon_r = 2$. The speed of an em wave in this medium is $c/2$.

Statement-II: The speed of an em wave in a medium for which $\mu_r = 2$ is $c/\sqrt{2}$, then the dielectric constant of this medium would be $\varepsilon_r = 1$.

1. Statement I is correct, Statement II is correct
2. Statement I is incorrect, Statement II is incorrect
3. Statement I is correct, Statement II is incorrect
4. Statement I is incorrect, Statement II is correct

$\frac{1}{2} \times 2 = 1$

$n = \sqrt{0.5 \times 2} = \sqrt{1} = 1$

$n = \sqrt{2}$

$n = \frac{c}{v} = 1$

$v = c$

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

QUESTION

Assertion: On entering an em wave into a medium with properties, $\varepsilon_r = 2$, $\mu_r = 2$, the speed of the wave becomes half.

Reason: For a medium refractive index can be given by $n = \sqrt{\mu_r \varepsilon_r}$, and speed of wave $v \propto 1/n$.

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)
2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)
3. Assertion (A) is True, Reason (R) is False.
4. Assertion (A) is False, Reason (R) is True.

QUESTION

Electric field of a plane electromagnetic wave propagating through a non-magnetic medium is given by $E = 20\cos(2 \times 10^{10} t - 200x)$ V/m. The dielectric constant of the medium is equal to: (Take $\mu_r = 1$) [1 Sept, 2021 (Shift-II)]

1. 1/3
2. 3
3. 2
4. 9

$\epsilon_r = ?$

$v = \frac{2 \times 10^{10}}{200} = 10^8$

$n = \frac{c}{v} = \sqrt{\mu_r \epsilon_r}$

$n = \frac{3 \times 10^8}{10^8} = 3 = \sqrt{1 \times \epsilon_r}$

$3 = \sqrt{\epsilon_r}$

$9 = \epsilon_r$

QUESTION

HW

If ε_0 and μ_0 are respectively the electric permittivity and magnetic permeability of free space, ε and μ are the corresponding quantities in a medium, the index of refraction of the medium is

[CBSE AIPMT 1997]

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

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

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

(4) $\sqrt{\frac{\varepsilon}{\varepsilon_0}}$

QUESTION

HW

Given below are two statements:

Statement-I: Electromagnetic waves are not deflected by electric and magnetic field.

Statement-II: The amplitude of electric field and the magnetic field in electromagnetic waves are related to each other as $E_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} B_0$

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

[29 Jan, 2023 (Shift-II)]

1. Statement-I is true but Statement-II is false
2. Both Statement-I and Statement-II are true
3. Statement-I is false but Statement-II is true
4. Both Statement-I and Statement-II are false

Energy Density

Light is a form of energy.

$$u_E = \frac{1}{2}\epsilon_0 E^2 \longrightarrow (u_E)_{av} = \frac{1}{4}\epsilon_0 E_0^2$$

$$u_B = \frac{1}{2}\frac{B^2}{\mu_0} \longrightarrow (u_B)_{av} = \frac{1}{4}\frac{B_0^2}{\mu_0}$$

Total energy density ←
$$u = u_E + u_B = \frac{1}{2}\epsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0} = \epsilon_0 E^2 = \frac{B^2}{\mu_0}$$

Total average energy density ←
$$u_{av} = (u_E)_{av} + (u_B)_{av} = \frac{1}{4}\epsilon_0 E_0^2 + \frac{1}{4}\frac{B_0^2}{\mu_0} = \frac{1}{2}\epsilon_0 E_0^2 = \frac{1}{2}\frac{B_0^2}{\mu_0}$$

Energy is equally divided b/w $\vec{E}$ & $\vec{B}$

$$E_0 = cB_0$$

$$\frac{x}{2} + \frac{x}{2} = x$$

$$\frac{x}{4} + \frac{x}{4} = \frac{x}{2}$$

QUESTION

The ratio of contributions made by the electric field and magnetic field components to the intensity of an electromagnetic wave is: (c = speed of electromagnetic waves)

[2020]

$\frac{\text{Energy}}{\text{Area} \times \text{time}}$

1. $1 : 1$
2. $1 : c$
3. $1 : c^2$
4. $c : 1$

QUESTION

The electric field of a plane electromagnetic wave of amplitude 2 V m^{-1} varies with time and propagates along *z*-axis. The average energy density of the magnetic field (in J m^{-3}) is [AIIMS 2019]

$E_0 = 2$

(1) 13.29×10^{-12}

$(u_B)_{av} = \frac{1}{4}\frac{B_0^2}{\mu_0} = \frac{1}{4}\epsilon_0 E_0^2 = (u_E)_{av}$

(2) 8.86×10^{-12}

$= \frac{1}{4} \times 8.85 \times 10^{-12} \times 2^2$

(3) 17.72×10^{-12}

$= 8.85 \times 10^{-12}$

(4) 4.43×10^{-12}

QUESTION

$\rightarrow E_0 = 50$

The electric field in an electromagnetic wave is given by $E = (50\ NC^{-1}) \sin\omega\,(t - x/c)$. The energy contained in a cylinder of volume V is 5.5×10^{-12} J. The value of V is 500 cm^3. (given by $\epsilon_0 = 8.8 \times 10^{-12}\ C^2N^{-1}m^{-2}$) **[31 Aug, 2021 (Shift-I)]**

$$(U_{av})_{Total} = \frac{1}{2}\epsilon_0 E_0^2 = \frac{U}{\text{Volume}}$$

Volume = V

$$\text{Volume} = \frac{U}{\frac{1}{2}\epsilon_0 E_0^2} = \frac{5.5 \times 10^{-12}}{\frac{1}{2} \times 8.8 \times 10^{-12} \times 50^2}$$

$$\Rightarrow m^3 \times 10^6 \Rightarrow cm^3$$

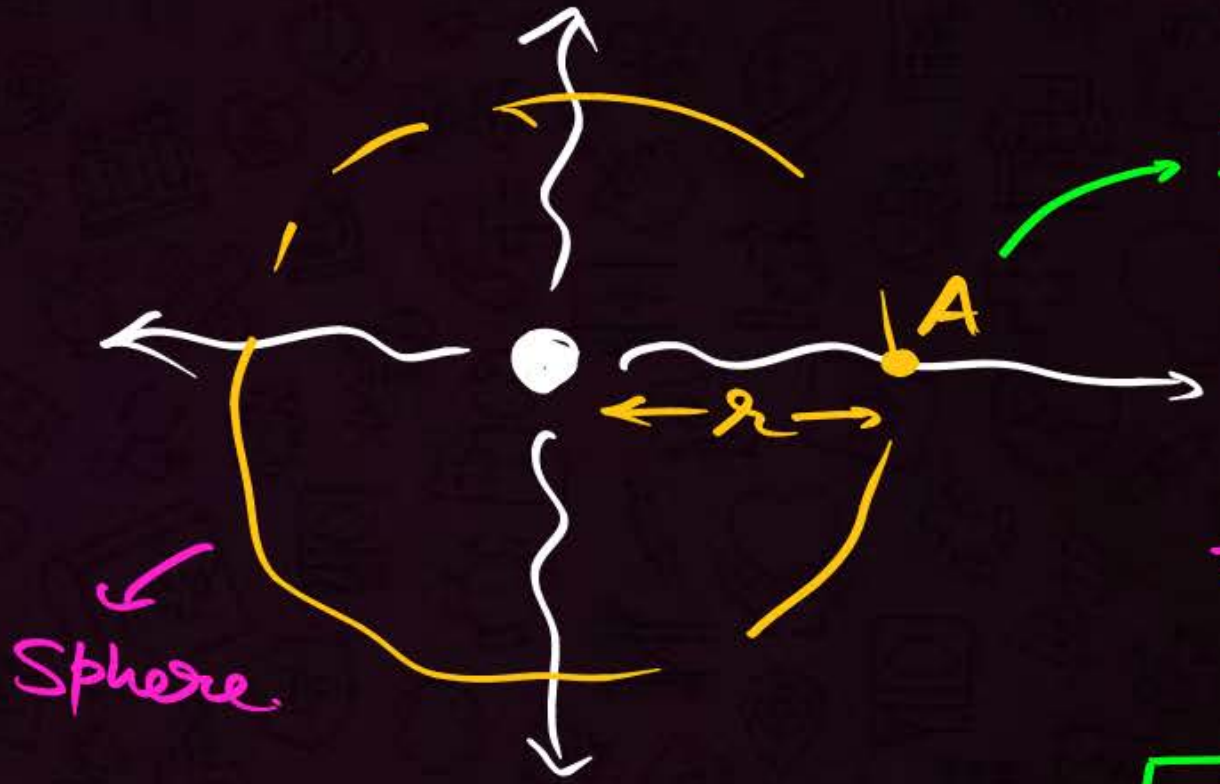
Intensity of EM Wave

$$I = uC$$

$$I_{av} = u_{av}\, C$$

u_{av} → Total, C → Total

Point Source (eg: Bulb)



Intensity $= \frac{\text{Energy}}{\text{time} \times \text{Area}} = \frac{\text{Power}}{\text{Area}}$

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

Bulb power = P

$$I_{av} = \frac{P_{av}}{4\pi r^2}$$

$$I \propto \frac{1}{r^2}$$

$E_0 = ?$

$B_0 = ?$

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

$$I_{av} = u_{av}\, c = \frac{P_{av}}{4\pi r^2}$$

$$\frac{1}{2}\epsilon_0 E_0^2 c = \frac{P_{av}}{4\pi r^2}$$

$$E_0^2 = \frac{2P_{av}}{4\pi\epsilon_0 c r^2}$$

$$E_0^2 = \frac{2kP_{av}}{cr^2}$$

TBS

$$E_0 = \sqrt{\frac{2kP_{av}}{cr^2}}$$

QUESTION

The electric field intensity produced by the radiation coming from a 100 W bulb at a distance of 3m is E. The electric field intensity produced by the radiation coming from 60 W at the same distance is $\sqrt{\frac{x}{5}}E$. The value of x = ______.   [17 March, 2021 (Shift-II)]

A) 100
B) 60
C) 3
D) 5.

$E = \sqrt{\frac{2kP_{av}}{cr^2}}$

$E \propto \sqrt{P}$

$P_1 = 100W$ — 3m — E_1

$P_2 = 60W$ — 3m — $E_2 = ?$

$\frac{E_2}{E_1} = \sqrt{\frac{P_2}{P_1}}$

$\frac{E_2}{E} = \sqrt{\frac{60}{100}} = \sqrt{\frac{3}{5}}$

$E_2 = \sqrt{\frac{3}{5}}E$

QUESTION

A point source of electromagnetic radiation has an average power output of 1500 W. The maximum value of electric field at a distance of 3 m from this sources in Vm^{-1} is

(1) 500

(2) 100

(3) 500/3

(4) 250/3

E_0

$P_{av} = 1500\,W$

$r = 3\,m$

$r^2 = 9$

TBS $\rightarrow \sqrt{\frac{2kP_{av}}{cr^2}}$

$= \sqrt{\frac{2\times 9\times 10^{9}\times 1500}{3\times 10^{8}\times 9}}$

$100 = \sqrt{10000} = \sqrt{\frac{2\times 10\times 1500}{3}} = \sqrt{\frac{3000\times 10}{3}}$

Topic → Radiation Pressure

↳ $\frac{2I}{c}$

• Other sources than point source

→ Dual Nature of Radiation & Matter

Electromagnetic Spectrum

optional

1.	Radio Waves	Rashmika	<	10^9 Hz
2.	Micro Waves	Madhana	=	$10^9 - 3 \times 10^{11}$ Hz
3.	Infrared	is	=	$3 \times 10^{11} - 4 \times 10^{14}$ Hz
4.	Visible	very	=	$4 \times 10^{14} - 7 \times 10^{14}$ Hz
5.	Ultraviolet	unique	=	$7 \times 10^{14} - 10^{16}$ Hz
6.	X-ray	Ex.	=	$10^{16} - 10^{19}$ Hz
7.	Gamma Rays	(γ)	>	10^{19} Hz

γ → Girl-friend

$$E = h\nu = \frac{hc}{\lambda}$$

$\nu \uparrow \Rightarrow E \uparrow$

→ $\lambda \downarrow$

λ decreases

f (ν) increase

E increases

Compulsory → Wavelength range

1.	Radio Waves	$> 10^{-1}$ m = 0.1 m
2.	Micro Waves	$= 10^{-3} - 10^{-1}$ m
3.	Infrared	$= 7 \times 10^{-7} - 10^{-3}$ m
4.	Visible	$= 4 \times 10^{-7} - 7 \times 10^{-7}$ m
5.	Ultraviolet	$= 10^{-8} - 4 \times 10^{-7}$ m
6.	X-ray	$= 10^{-11} - 10^{-8}$ m
7.	Gamma Rays	$< 10^{-11}$ m

R O Y G B I V

λ inc ↑

f inc ↓

$\nu = \frac{c}{\lambda}$

$\lambda = \frac{c}{\nu}$

Generally

X-ray ⇒ E → keV

γ-ray ⇒ E → MeV

* VISIBLE

VIBGYOR

⟶ λ inc.

f inc. ⟵

2019 PYQ

λ_{max} = Red

QUESTION

Which of the following electromagnetic radiations has the least wavelength? [2002]

↳ f max.

1. Gamma rays
2. Infra-red
3. ultraviolet
4. X-rays

QUESTION

In general, the wavelength of microwaves, is [AIIMS 1996]

1. more than that of infrared waves
2. more than that of radio waves
3. less than that of infrared waves
4. less than that of ultraviolet waves.

QUESTION

Which colour of the light has the longest wavelength? [2019]

(1) red

(2) blue

(3) green

(4) violet

QUESTION

HW

The decreasing order of wavelength of infrared, microwave, ultraviolet and gamma rays is [2011]

1. microwave, infrared, ultraviolet, gamma rays
2. gamma rays, ultraviolet, infrared, microwaves
3. microwaves, gamma rays, infrared, ultraviolet
4. infrared, microwave, ultraviolet, gamma rays

QUESTION

The frequency order for X-rays (A), γ-rays (B), UV rays (C) is [AIIMS 2012]

1. B > A > C
2. A > B > C
3. C > B > A
4. A > C > B

B > A > C

QUESTION

Out of the following, choose the ray which does not travel with the velocity of light

1. X-rays
2. Microwave
3. γ-rays
4. β-rays

→ Light

→ electron

QUESTION

v_γ, v_x and v_m are the speeds of gamma rays, X-rays and microwaves respectively in vacuum, then

[AIIMS 2009]

1. $v_\gamma > v_x > v_m$
2. $v_\gamma < v_x < v_m$
3. $v_\gamma < v_x > v_m$
4. $v_\gamma = v_x = v_m$ $= c$

QUESTION

The velocity of electromagnetic waves in free space is 3×10^8 m sec^{-1}. The frequency of a radio wave of wavelength 150 m, is [AIIMS 1996]

(1) 20 kHz

(2) 45 MHz

(3) 2 kHz

(4) 2 MHz

$$\nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{150} = \frac{300 \times 10^6}{150}$$

$$= 2 \times 10^6 \text{ Hz}$$

$$= 2 \text{ MHz}$$

QUESTION

HW

The wavelength of light of frequency 100 Hz is [CBSE AIPMT 1999]

1. 2×10^6 m
2. 3×10^6 m
3. 4×10^6 m
4. 5×10^6 m

QUESTION

Which of the following is the infrared wavelength? [AIIMS 1997]

(1) 10^{-4} cm $= 10^{-6}$ m.

(2) 10^{-5} cm $= 10^{-7}$ m → Border

(3) 10^{-6} cm $= 10^{-8}$ m

(4) 10^{-7} cm $= 10^{-9}$ m

$7 \times 10^{-7} - 10^{-3}$

↓

10^{-6}

QUESTION

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. γ-rays
4. X-rays (TBS)

Dual Nature ⇒ $E = \frac{hc}{\lambda} = \frac{12400}{\lambda}$ (E → eV, λ → A°)

$\lambda = \frac{12400}{E} = \frac{12400}{15000} = \frac{124}{150} \simeq \frac{125}{150}$

$= \frac{5}{6} A° = 0.83 A°$

$10^{-11} m - 10^{-8} m$

$10^{-1} A° - 10^{2} A°$

$0.1 A° - 100 A°$

QUESTION

The correct match between the entries in column I and column II are:

[5 Sep, 2020 (Shift-II)]

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

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

QUESTION

HW

Match List-I with List-II of Electromagnetic waves with corresponding wavelength range: [15 April, 2023 (Shift-1)]

Choose the correct answer from the options given below:

List-I		List-II	
(A)	Microwave	(I)	400 nm to 1 nm
(B)	Ultraviolet	(II)	1 nm to 10^{-3} nm
(C)	X-Ray	(III)	1 mm to 700 nm
(D)	Infra-red	(IV)	0.1 m to 1 mm

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

1. Radio Waves

It is produced by the accelerated motion of charges in conducting wires. (i.e., by oscillating electric charge).

oscillating charge

Used in radio and T.V. communication.

2. Microwaves

It is produced by special vacuum tubes (called Klystrons, Magnetrons and Gunn diodes)

→ semi-conductor.

(1) It is used to detect speed of tennis ball, cricket ball, automobile.

→ Use of Doppler's Effect.

(2) It is used in microwave ovens.

↓

resonance

↓

f match

$f_{water} = f_{micro\text{-}wave}$ → Heat produced

Water (H_2O)

↓

f

3. Infrared

- It is produced by hot bodies i.e. vibrations of atoms and molecules. (Hence also called heatwaves).
- It is not detected by human eye but snake can detect it.

  Humans emit it.

- Used to see through fog and smoke, muscular pain
- It is responsible for keeping average temperature through green-house effect.

4. Visible

It is a narrow range of electromagnetic spectrum

→ 4×10^{-7} m – 7×10^{-7} m

It is produced when electrons jump to lower level.

Electronic Transition.

5. Ultra-Violet

- It is produced by sun, special lamps and very hot bodies.
- It is produced when electrons jump to lower level → electronic transition
- Most of the ultraviolet radiations coming from the sun are absorbed by the ozone layer in the earth's atmosphere.
- The UV rays in large quantity produce harmful effect on human being, it causes production of melanin, tanning of the skin.
- It is used in water purifiers. → Kent RO → germs kill.
- Laser Eye Surgery

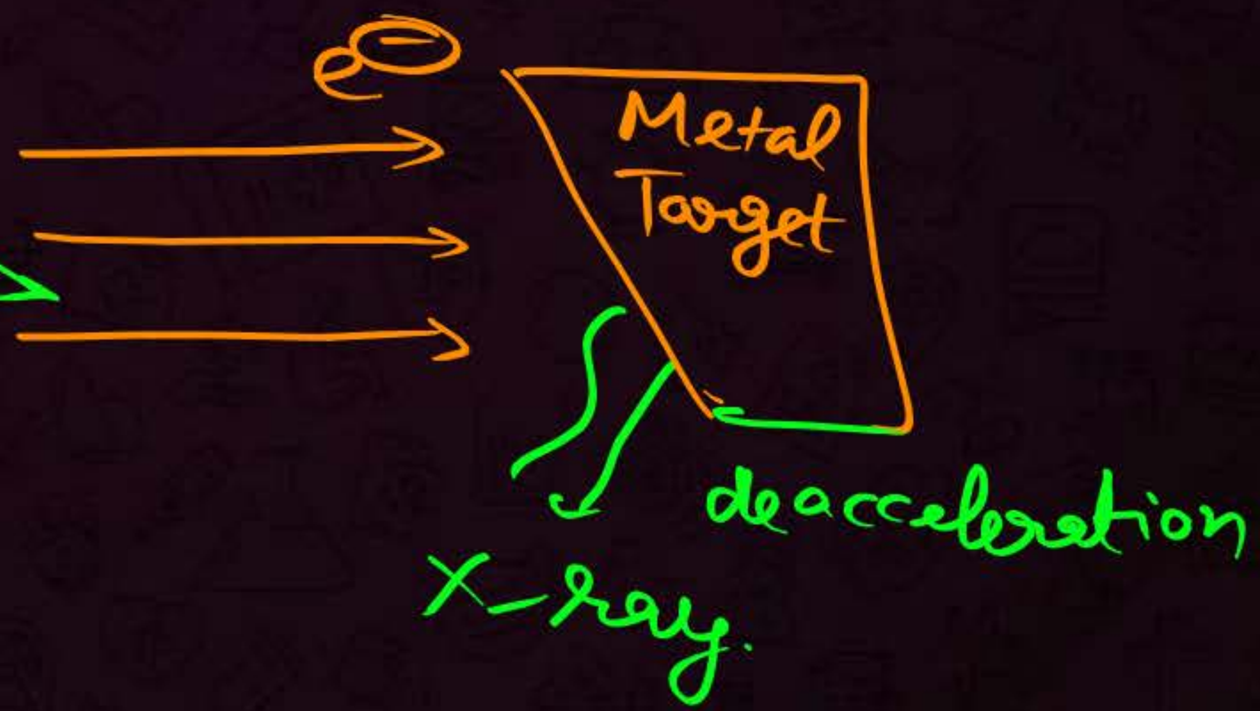
6. X-Ray

It is produced in a tube called modern X-ray tube and electronic transition.

X-ray are used as a diagnostic tool in medicine

In engineering it is used for detecting faults, cracks, flaws and holes.

Cancer Treatment.



7. Gamma Rays

It is high frequency radiation which is produced in nuclear reactions they are emitted by radioactive nuclei.

nuclear decay

They are used for cancer therapy.

They provide important information regarding nuclear structure.

QUESTION

The condition under which a microwave oven heats up a food item containing water molecules most efficiently is [2013]

(1) The frequency of the microwaves has no relation with natural frequency of water molecules.

(2) Microwaves are heat waves, so always produce heating.

(3) infra-red waves produce heating in a microwave oven.

(4) The frequency of the microwaves must match the resonant frequency of the water molecules.

QUESTION

Assertion: Environmental damage has increased the amount of ozone in the atmosphere.

Reason: Increase of ozone increases the amount of ultraviolet radiation on earth.

Decrease

[AIIMS 1996]

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)
2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)
3. Assertion (A) is True, Reason (R) is False.
4. Assertion (A) is False, Reason (R) is True. False

QUESTION

Biological importance of Ozone layer is: [2001]

1. It stops ultraviolet rays
2. Ozone layer reduces green house effect
3. Ozone layer reflects radio waves
4. Ozone layer controls O_2/H_2 ratio in atmosphere

QUESTION

HW

Match the List-I with List-II: [27 June, 2022 (Shift-I)]

Choose the correct answer from the options given below:

List-I		List-II	
A.	Ultraviolet rays	p.	Study crystal
B.	Microwaves	q.	Greenhouse effect
C.	Infrared waves	r.	Sterilizing surgical
D.	X-rays	s.	Radar system

1. $A \to (r), B \to (s), C \to (q), D \to (p)$
2. $A \to (q), B \to (p), C \to (s), D \to (r)$
3. $A \to (r), B \to (q), C \to (p), D \to (s)$
4. $A \to (q), B \to (p), C \to (r), D \to (s)$

QUESTION

Match the List-I with List-II: [31 Jan 2023 (Shift-II)]

Choose the correct answer from the options given below:

List-I		List-II	
(A)	Microwave	(I)	Physiotherapy
(B)	UV rays	(II)	Treatment of cancer
(C)	Infra-red rays	(III)	Lasik eye surgery
(D)	X-rays	(IV)	Aircraft navigation (RADAR)

1. A → II, B → IV, C → III, D → I
2. A → IV, B → I, C → II, D → III
3. A → IV, B → III, C → I, D → II
4. A → III, B → II, C → I, D → IV

QUESTION

HW

Match the List-I with List-II: [01 Feb 2023 (Shift-I)]

Choose the correct answer from the options given below:

List-I		List-II	
(A)	Microwave	(I)	Radio active decay of the nucleus
(B)	Gamma rays	(II)	Rapid acceleration and deceleration of electron in aerials (means oscillation)
(C)	Radio waves	(III)	Inner shell electrons
(D)	X-rays	(IV)	Klystron valve

1. $A \rightarrow I, B \rightarrow II, C \rightarrow III, D \rightarrow IV$
2. $A \rightarrow IV, B \rightarrow I, C \rightarrow II, D \rightarrow III$
3. $A \rightarrow I, B \rightarrow III, C \rightarrow IV, D \rightarrow II$
4. $A \rightarrow IV, B \rightarrow III, C \rightarrow II, D \rightarrow I$

QUESTION

The structure of solids is investigated by using [1992]

1. Cosmic rays
2. X-rays
3. γ-rays
4. Infra-red radiations

QUESTION

The temperature of an object that emits electromagnetic radiation must be [AIIMS 2013]

T > 0K

1. higher than 0°C
2. higher than 0 K
3. higher than that of its surroundings
4. high enough for it to glow.

QUESTION

HW

We consider the radiation emitted by the human body. Which of the following statements is true? [2003]

(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.

QUESTION

HW

Assertion: Gamma rays are more energetic than X-rays.

Reason: Gamma rays are of nuclear origin but X-rays are produced due to sudden deceleration of high energy electrons while falling on a metal of high atomic number.

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)
2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)
3. Assertion (A) is True, Reason (R) is False.
4. Assertion (A) is False, Reason (R) is True.

QUESTION

Green-house effect is the heating up of earth's atmosphere due to [2002]

1. Green plants
2. Infra-red rays
3. X-rays
4. Ultraviolet rays

QUESTION

HW

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

List 1		List 2	
1.	Infrared waves	(i)	To treat muscular strain
2.	radio waves	(ii)	For broadcasting
3.	X-rays	(iii)	To detect fracture of bones
4.	Ultraviolet rays	(iv)	Absorbed by the ozone layer of the atmosphere

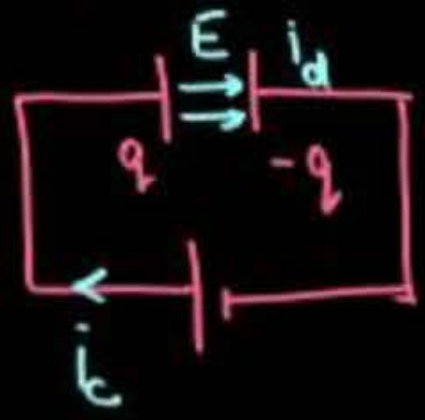
TBS Capsule ①

* EM Waves → Light Waves
* Non-Mechanical
* Concept

Change in B → produces E

Change in E → produces B

*



$i_d = i_c$

↓

Continuity of current

• E changes inside capacitor while charging

---

* $i_d = \frac{dq}{dt} = C\frac{dV}{dt} = \epsilon_0 \frac{d\phi_E}{dt} = \epsilon_0 A \frac{dE}{dt}$

① $\oint \vec{E} \cdot \vec{ds} = \frac{q_{encl}}{\epsilon_0}$ → Gauss Law in Electrostatics
→ Coulomb's Law can be verified

② $\oint \vec{B} \cdot \vec{ds} = 0$ → Gauss Law in Magnetism
→ Magnetic monopoles do not exist

③ $\oint \vec{E} \cdot \vec{dl} = -\frac{d\phi_B}{dt}$ → Faraday's Law of EMI
Induced Electric field

④ $\oint \vec{B} \cdot \vec{dl} = \mu_0 (i_c + i_d) = \mu_0 \left(i_c + \epsilon_0 \frac{d\phi_E}{dt} \right)$

↳ Modified Ampere's Law
↳ Ampere-Maxwell law.

Inside capacitor
↓
$i_c = 0$

Outside capacitor
↓
$i_d = 0$

⑤ $\vec{F} = \vec{F_e} + \vec{F_b} = q(\vec{E} + \vec{v} \times \vec{B})$

Lorrentz Force Eqn

4 eqns of Maxwell + Lorrentz Force Eqn = Whole Electromagnetism

TBS Capsule (2)

* charge at rest → produces $\vec{E}$
* charge moving with constant v → produces $\vec{E}$ & $\vec{B}$
* accelerating charge (eg: oscillating charge) ↓ produces $\vec{E}, \vec{B}$ & EM Waves.

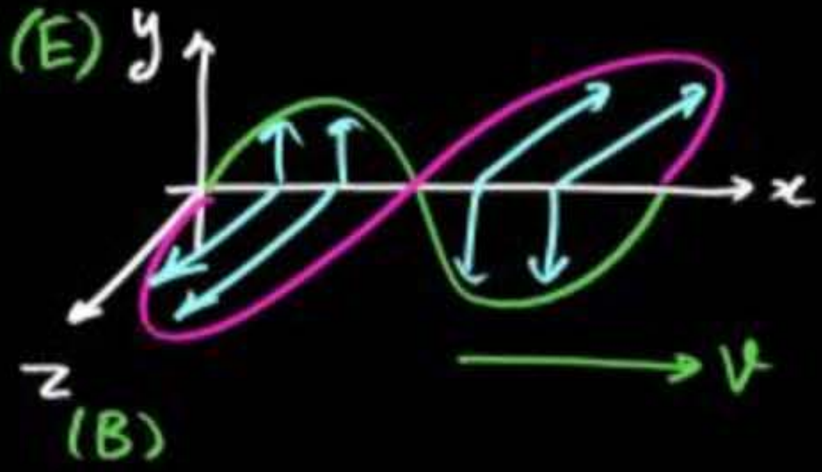
* Basics of Wave motion

$y = A\sin(\omega t - kx) \Rightarrow$ Direction $\Rightarrow +x$

$y = A\sin(\omega t + kx) \Rightarrow$ Direction $\Rightarrow -x$

* $v = \frac{\lambda}{T} = \frac{\omega}{k} = f\lambda$ | $\omega = 2\pi f$, $k = \frac{2\pi}{\lambda}$

* Equation of EM Wave



$E_y = E_0 \sin(\omega t - kx)$

$B_z = B_0 \sin(\omega t - kx)$

* $E_0 = CB_0$ * $E_{av} = CB_{av}$
* $E_{rms} = C B_{rms}$

↓ in vacuum

Properties

1. E & B → same phase $\Delta\phi = 0$
2. $\vec{E}$ & $\vec{B}$ ⊥cular to each other, also ⊥cular to direction of propagation.
3. do not require medium to travel.
4. $C = 3\times10^8$ m/s $= \frac{1}{\sqrt{\mu_0 \epsilon_0}}$ (in vacuum)
5. $v = \frac{1}{\sqrt{\mu\epsilon}}$ in medium

$n = \frac{c}{v} = \sqrt{\mu_r \epsilon_r}$

(6) $\vec{E}$ is optical vector

(7) Polarization ✓

(8) Do not get deflected

* Energy density

$$u_E = \frac{1}{2}\epsilon_0 E^2, \quad u_B = \frac{1}{2}\frac{B^2}{\mu_0}$$

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

$$(u_E)_{av} = \frac{1}{4}\epsilon_0 E_0^2, \quad (u_B)_{av} = \frac{1}{4}\frac{B_0^2}{\mu_0}$$

$$(u)_{av} = \frac{1}{4}\epsilon_0 E_0^2 + \frac{1}{4}\frac{B_0^2}{\mu_0} = \frac{1}{2}\epsilon_0 E_0^2 = \frac{1}{2}\frac{B_0^2}{\mu_0}$$

* energy equally divided b/w $\vec{E}$ & $\vec{B}$

* $I = uc$ $\quad$ $I_{av} = u_{av} c$

* $I = \frac{P}{4\pi r^2}$ $\quad$ $I_{av} = \frac{P_{av}}{4\pi r^2}$ → Point Source

* $E_0 = \sqrt{\frac{2k P_{av}}{c r^2}}$ → TBS

* $\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0}$ → Poynting vector

Intensity in vector form

TBS Capsule (3)

1.	Radio Waves	$< 10^9$ Hz
2.	Micro Waves	$= 10^9 - 3 \times 10^{11}$ Hz
3.	Infrared	$= 3 \times 10^{11} - 4 \times 10^{14}$ Hz
4.	Visible	$= 4 \times 10^{14} - 7 \times 10^{14}$ Hz
5.	Ultraviolet	$= 7 \times 10^{14} - 10^{16}$ Hz
6.	X-ray	$= 10^{16} - 10^{19}$ Hz
7.	Gamma Rays	$> 10^{19}$ Hz

1.	Radio Waves	$> 10^{-1}$ m
2.	Micro Waves	$= 10^{-3} - 10^{-1}$ m
3.	Infrared	$= 7 \times 10^{-7} - 10^{-3}$ m
4.	Visible	$= 4 \times 10^{-7} - 7 \times 10^{-7}$ m
5.	Ultraviolet	$= 10^{-8} - 4 \times 10^{-7}$ m
6.	X-ray	$= 10^{-11} - 10^{-8}$ m
7.	Gamma Rays	$< 10^{-11}$ m

ν (f) increases

$E = h\nu$ increases

λ decreases.

$$E = h\nu = hf$$

$$c = \nu\lambda = f\lambda$$

- X-ray ⇒ E ⇒ keV
- γ-ray ⇒ E ⇒ MeV
- Visible → VIBGYOR

VIBGYOR → λ inc.

← f inc.

Waves	Production	Uses & Effects
① Radio Waves	accelerated charges	Radio, TV
② Microwaves	vacuum tubes (Klystron, Magnetron, Gunn diodes)	oven, speed of ball, automobile
③ Infrared	Hot bodies, Vibration of atoms	* See through fog & smoke * muscular pain treat * green house effect
④ Visible	Electronic transition	* See the world through these
⑤ UV	Sun, Special lamps very hot bodies, Electronic transition	* Ozone depletion, Tanning of skin * water purifier, Laser Eye Treatment
⑥ X-ray	Electoonic transition de-acceleration of charge on target	* diagonstic tool → bone fracture * Cancer treat | * Fault, crack, holes find
⑦ γ-ray	Nuclear rxns Nuclear decay	* Cancer treat * Tell Nuclear structure

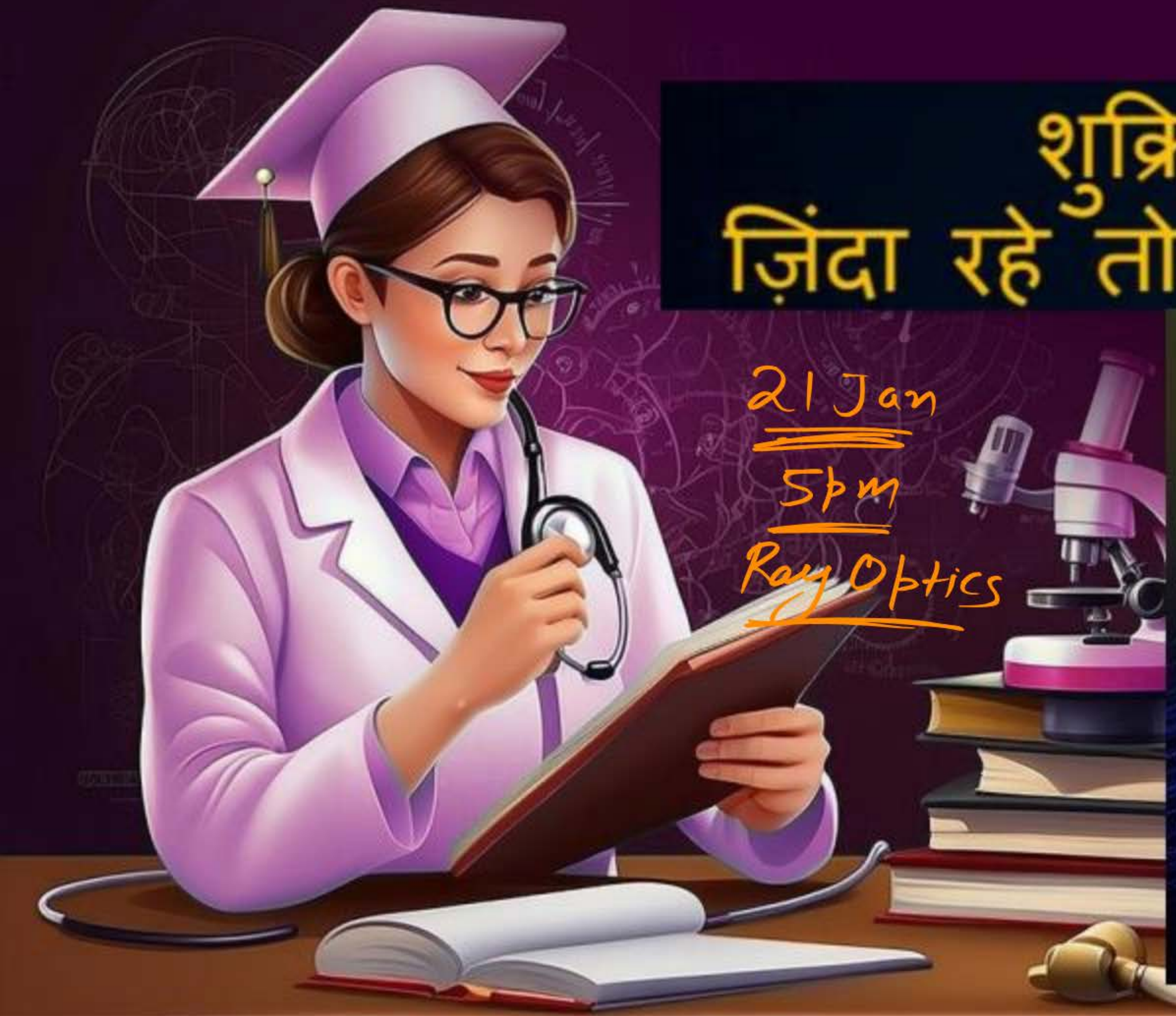
Homework

Kal Subah 10 Bje - DPP Battle – Ground

Topic Radiation Pressure in Dual Nature of Radiation and Matter

FOR NOTES & DPP CHECK DESCRIPTION

शुक्रिया !
ज़िंदा रहे तो फिर मिलेंगे



21 Jan

5pm

Ray Optics

@PHYSICSBY_TANUJSIR