ToppersNotes

CBSE

CLASS-XII

PHYSICS

PART - II

Sierra Innovations Pvt. Ltd.

Physics II

Contents **Page No**

Electromagnetic Waves	1-12
Ray Optics and Optical Instruments	13-102
Wave Optics	103-143
Semiconductor Electronics	144-198
Photoelectric effect & Dual Nature of Matter	199-212
Atoms & Nuclear Physics	213-246
Communication Systems	247-271

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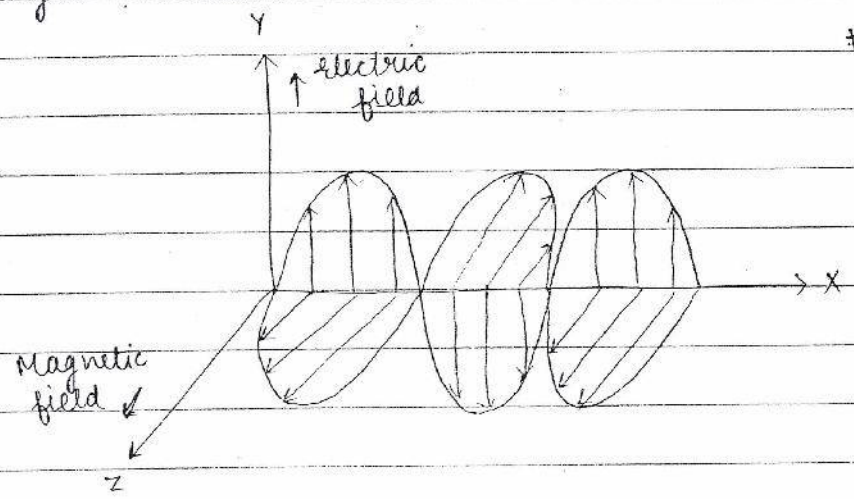
ELECTRO MAGNETIC WAVES (3 Marks)

* Electro Magnetic wave :
A wave which consist of electric and magnetic vibrations and do not require any material medium for propogation is known as electro magnetic waves.



CONDITION
Electric field and magnetic field should be variable

* Properties of Electro Magnetic waves :

1. It doesn't require any material medium for propogation.

2. Electro magnetic waves propogates in the form of varying electric field and magnetic field such that two fields are ⊥ to each other, and also the direction of propagation, means electro magnetic wave is a transverse wave.

3. Electro magnetic waves are produced by accelerated charge particle.

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4. In free space speed of EMW

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

In air

μ_0 = permeability in free space and
ϵ_0 = permittivity in free space.

In Medium $V = \frac{1}{\sqrt{\mu \epsilon}}$ where, μ = permeability in medium
ϵ = permittivity in medium

5. EMW follows super position principle

6. The ratio of variation in amplitude of electric field and magnetic field at same time and at same point is provide the value of speed of E.M.W.

Free space $c = \frac{E_0}{B_0}$ For Medium $V = \frac{E}{B}$

7 The energy of EMW is divided equally b/w electric and magnetic field vector.

Average electric energy density $= \frac{1}{2} \epsilon_0 E^2$

Average magnetic energy density $= \frac{1}{2} \frac{B^2}{\mu_0}$

8 Electric vector is responsible for optical effect due to EMW that's why electric vector is called light vector.

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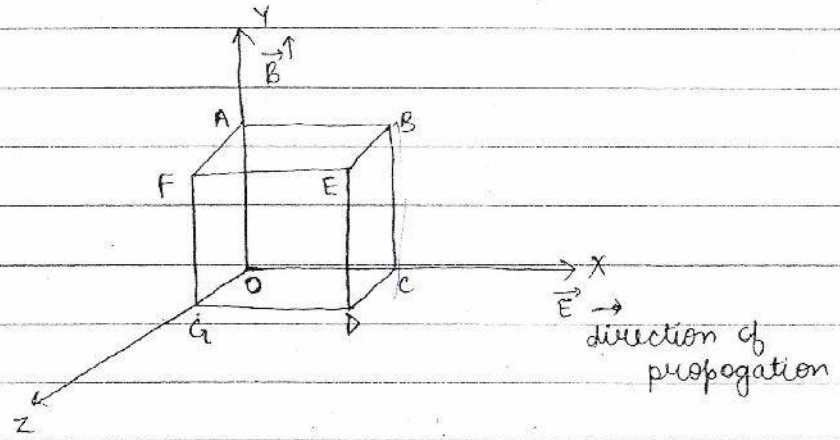
9. The intensity of EMW

$$I = \frac{E_0 B_0}{2\mu_0}$$

Ques show that Electro Magnetic wave is transverse in nature.



consider that electro magnetic wave is travelling in x- direction. Electric field vector is considered in x- direction. A cube ABCDEFGO is shown in diagram.

using Gauss law

$$\oint \vec{E}\cdot d\vec{A} = 4\pi K \Sigma q$$

Here $\Sigma q = 0$

$$\oint \vec{E}\cdot d\vec{A} = 0$$

$$\left(\int_{BCDE} \vec{E}\cdot d\vec{A} + \int_{OAFG} \vec{E}\cdot d\vec{A}\right) + \left(\int_{ABEF} \vec{E}\cdot d\vec{A} + \int_{OCDG} \vec{E}\cdot d\vec{A}\right) + \left(\int_{ABCO} \vec{E}\cdot d\vec{A} + \int_{FEDG} \vec{E}\cdot d\vec{A}\right) = 0$$

$$\left(\int_{BCDE} EdA\cos 0^\circ + \int_{OAFG} EdA\cos 180^\circ\right) + \left(\int_{ABEF} EdA\cos 90^\circ + \int_{OCDG} EdA\cos 90^\circ\right) +$$

$$\left(\int_{ABCO} EdA\cos 90^\circ + \int_{FEDG} EdA\cos 90^\circ\right) = 0$$

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$$\int_{BCDE} E'_x \, dA - \int_{OAFG} E_x \, dA + 0 + 0 + 0 + 0 = 0$$

$$\int_{BCDE} E'_x \, dA - \int_{OAFG} E_x \, dA = 0$$

$$\int_{BCDE} E'_x \, dA = \int_{OAFG} E_x \, dA$$

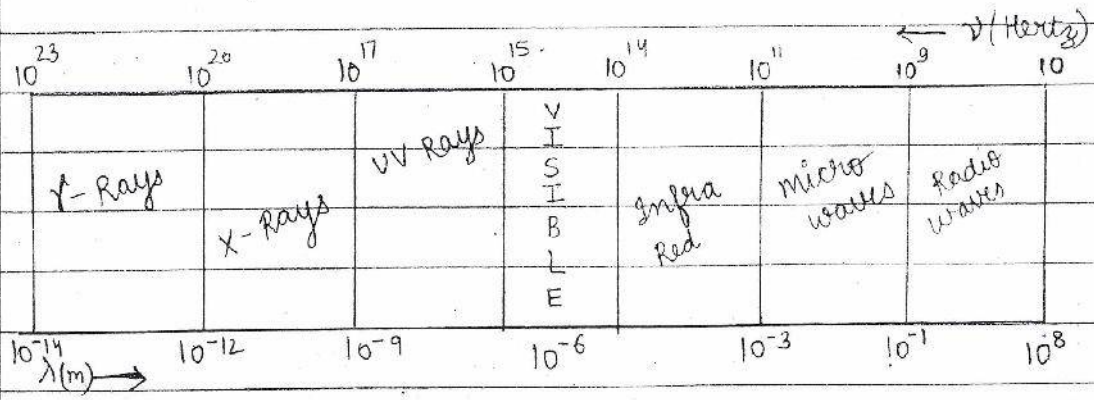
$$E_x = E'_x$$

This is the contradict condition of production of electromagnetic wave. so our assumption of consideration of electric field in the direction of wave propogation is wrong. so we have to consider electric field $\perp$ to the direction of propogation.

Hence EMW is transverse in nature.

★ Electro magnetic Spectrum:

The complete range of frequencies / wavelength of the EMW arranged in an order is known as electro magnetic spectrum.



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1 Radio waves :

- Frequency range $10 - 10^9$ Hz
- wavelength range $10^{-1} - 10^8$ m
- Production:

Rapid acceleration and deacceleration of e^-(s) in aerials (Radio waves are produced by rapid changing the electric current in LC circuit).

- Uses:

Radio waves mainly used for communication purpose.

(a) very low frequency radio waves (10 KHz - 30 KHz)
→ Used in point to point short distance communication.

(b) Low frequency radio waves (30 KHz - 300 KHz)
→ used of navigation / marine communication.

(c) Medium frequency radiowaves (300 KHz - 3000 KHz)
→ used in amplitude modulated broadcasting.

(d) High frequency (3MHz - 50 MHz)
→ Used for long distance communication.

(e) very high frequency (VHF) (50MHz - 300 MHz)
→ Used for FM transmission, radar and television broadcasting.

(f) ultra high frequency (UHF) (300 MHz - 3000 MHz)
→ Used for long distance communication, cellular phone make use of UHF radio, and also in TV broadcasting.

- Detection: Recievers aerial

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2. Micro waves: 26 29 30

- Frequency range $10^9 - 10^{11}$ Hz
- Wavelength range $10^{-3} - 10^{-1}$ m
- Production:

Klystron valve ~~and~~ or magnetron valve.

- Detection:

By point contact diodes.

- Uses:

Micro waves are called short wavelength radiowaves which are produced by vaccum tubes. These waves are used in:

→ Radar system.
→ used for navigation.
→ used in study of atomic and molecular structure.
→ used in microwave oven for cooking system.
→ used to measure the speed of vehicle, speed of cricket ball.

3. Infra Red:

- Frequency range → $10^{11} - 10^{14}$ Hz
- wavelength range → $10^{-6} - 10^{-3}$ m
- Production:

vibrations of atoms and molecules.

- Detection:

Infrared photographic film, thermopiles, bolometer.

- Uses:

These waves are also called heat waves.

→ In weather forecasting.
→ In satellite for army purpose.
→ Used in physical therapy.
→ used in solar water heater, solar cell etc
→ For producing dehydrated fruits.