(iii) After travelling a distance of lm, how will the amplitude of $\vec{H}$ reduce?

(iv) What is the direction of propagation of wave and $\hat{a}$? (4,5,6)

Given :

$\varepsilon_0 = 8.85 \times 10^{-12}$ Farad/m

$\mu_0 = 4\pi \times 10^{-7}$ Henry/m

$c = 3 \times 10^8$ m/s

$m_e = 9.11 \times 10^{-31}$ kg

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2935 **H**

Unique Paper Code : 32221601

Name of the Paper : Electromagnetic Theory

Name of the Course : **B.Sc. Hons. – (Physics)**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** is compulsory.
3. Answer any **four** of the remaining **six**.
4. Use of non-programmable scientific calculator is allowed.

1. Attempt any **five** questions :

(a) Explain the concept of displacement current by an example.

(b) Show that although the scalar and vector potentials are not unique in themselves, they define the Electric and Magnetic field uniquely.

(c) A 20 cm column of cane sugar solution of concentration 100 gm/litre produces rotation of 10.6°. Find the purity of cane sugar. Given: specific rotation of pure sugar is 66 $dm^{-1}\, g^{-1} cm^{-3}$.

(d) A phase retardation plate of quartz has thickness 0.1436 nm. For what wavelength in the visible region, it will act as quarter-wave plate? Given that $\mu_0 = 1.5443$ and $\mu_c = 1.5533$.

(e) Draw a schematic diagram for propagation of plane electromagnetic wave incident normally on a positive uni-axial crystal with its optic axis lying parallel to the plane of incidence and interface.

$$E = 120\ \mathrm{Cos}\left(\omega t + \frac{4\pi}{3}x\right)\hat{k}\ \mathrm{V/m},$$

$$H = \frac{120}{120\pi}\mathrm{Cos}\left(\omega t + \frac{4\pi}{3}x\right)\hat{j}\ \mathrm{A/m}$$

Determine the direction of power flow and the average power crossing the surface bounded by $y = 2$ m, $y = 0$, $z = 2$ m, and $z = 0$.

(c) Consider a medium for which $\vec{E}(z,t) = 10\, e^{-2z} \cos(10^8 t - 0.3z)\hat{i}$ and $\vec{H}(z,t) = H_0 e^{-az}\cos(\omega t - \beta z + \delta)\hat{a}$. Given that $\sigma = 4\ Sm^{-1}$, $\mu = 1.5\ \mu_0$, $\varepsilon = \varepsilon_0$

(i) What is the magnitude H_0 of the magnetic field?

(ii) Find the phase difference (δ) between $\vec{E}$ and $\vec{H}$ vectors.

(b) For a calcite crystal, the refractive indices of ordinary and extra ordinary rays are 1.65836 and 1.48641 at λ_0 = 5893 Å respectively. A left circularly polarized beam of this wavelength is incident normally on such crystal of thickness 5.141 μm having its optic axis cut parallel to the surface. What will be the state of polarization of the emergent beam? (9,6)

7. (a) Assume $\mu = \mu_0$, show that the ratio of the amplitudes of the conduction current density and displacement current density (a) is $\sigma/\omega\varepsilon$ for the applied field $E = E_0 \cos\omega t$. (b) What is the ratio of the amplitudes if the applied field is $E = E_0 e^{-t/\tau}$, where τ is real?

(b) The field vectors of a wave of frequency 200 MHz propagating in free space are given by

(f) The relative permittivity of distilled water is 81. Calculate the refractive index and velocity of light in it.

(g) Write the two limitations of Nicol prism.

(3×5)

2. (a) For the propagation of electromagnetic wave in anisotropic medium show that permittivity tensor is symmetric in nature.

(b) Discuss the construction of optical fiber. What is a step index and graded index in an optical fiber? Derive the expression of numerical aperture.

(8,7)

3. (a) Derive Fresnel's relation for reflection and transmission of plane electromagnetic waves at an interface between two dielectric media when an electric vector of the incident wave is perpendicular to the plane of incidence.

(b) Calculate the skin depth of electromagnetic waves of frequency 1 MHz incident on a good conductor having $\sigma = 5.8 \times 10^3$ mhom^{-1}. Assume that inside the conductor $\mu = \mu_0 = 4\pi \times 10^{-7}$ Hm^{-1}. (9,6)

4. (a) Derive the expressions for the components of electric and magnetic fields of a symmetric planar wave guide for transverse electric mode. Setup the Eigen value equation

(b) A dielectric waveguide of 15 μm film thickness has refractive index 1.53 and cover of refractive index 1.50. Calculate the maximum number of modes in the waveguide given free space wavelength $\lambda_0 = 2$ μm. (9,6)

5. (a) Distinguish between positive and negative crystals in terms of double refraction. How are these crystals used to make quarter wave plates? Explain how the quarter wave plate is used in producing elliptically and circularly polarized light.

(b) A step-index fiber has a core diameter of 80 μm, a core refractive index of 1.62, and a numerical aperture of 0.21. Calculate: (a) the acceptance angle, (b) the refractive index that the fiber can propagate at a wavelength of 0.8 μm, (c) the number of modes that the fiber can propagate at a wavelength of 0.8 μm. (9,6)

6. (a) Give an outline of Fresnel's explanation of optical rotation. How does optical rotation due to a material vary with wavelength?

P.T.O.