SET-B

Name of the Department : Physics
Name of the Course : B.Sc. (Hons.) Physics-CBCS_Core
Name of the Paper : Electromagnetic Theory
Semester : VI
Unique Paper Code : 32221601
Question paper Set number : B

Time : 2 Hours Maximum Marks : 75

Instructions for Candidates:

(a) Attempt any four questions.
(b) All questions carry equal Marks.

Q.1 Express Maxwell's equations in their differential form and give the physical significance of following (i) $\nabla . B = 0$ and (ii) $\nabla \times E = -\frac{\partial B}{\partial t}$. Show how Maxwell modified Ampere's law to, make it consistent with the equation of continuity. Obtain Maxwell's divergence equations from Maxwell's curl equations. Make use of Maxwell's equations to find out *D. B,* and *H,* if the electric field $E = 50\ cos\ (10^8 t + \phi x)\ a_y$ V/m in a medium having parameters $\sigma = 0$, $\varepsilon = 1\times 10^{-10}$ F/m , and $\mu = 2\times 10^{-8}$ H/m . Also sketch *E, H,* and direction of wave propagation.

Q.2. Starting from Maxwell's equations, show that in a conducting medium, the magnetic field lags behind the electric field. The intrinsic impedance of the given medium is $300\angle 35^o\ \Omega$ at a particular frequency. If at that frequency the plane wave propagating through this medium has the magnetic field component $H = 10\ e^{-\alpha x} cos\ (\omega t - 12x)\ \mathbf{a}_y$ A/m, find *E* and α. Determine the skin depth and wave polarization.

Q3. Derive the Fresnel's relations for reflection and refraction of a plane electromagnetic wave at a boundary separating two dielectric media, when the incident electric field vector is parallel to the plane of incidence. Also obtain the expression for Brewster's angle at an interface between two non-magnetic dielectric media. A plane interface between two

dielectrics is located at z = 0. In free space ($z \leq 0$), a plane wave with H=10 cos (10^8 t - kz) $\mathbf{a}_x$ mA/m is incident normally on a lossless medium ($\varepsilon = 2\varepsilon_o$, $\mu = 8\mu_o$) in region $z \geq 0$. Determine the reflected wave H_r, E_r and the transmitted wave H_t, E_t.

Q4. State Biot's laws for rotatory polarization . Using the Fresnel's theory of optical rotation, obtain the formula for the angle of rotation of plane of vibration. Give its experimental verification. Calculate the angle of rotation of polarization of light wave when it passes through a quartz plate of thickness 0.8 mm. The refractive index of the plate for right handed and left handed circularly polarized light of λ= 6000 Å are 1.66124 and 1.66118 respectively.

Q5. Using Maxwell's equations derive the wave equations for propagation of an electromagnetic wave in an inhomogeneous non-magnetic medium (ε varies along the x axis). Solve the appropriate wave equation for the TE modes in a step index symmetric planar dielectric wave guide. A dielectric waveguide of 20 μm film thickness has refractive index 1.522 and cover of refractive index 1.501. Find the maximum number of modes in the guide, given the free space wavelength λ_o= 3μm.

6. Explain the construction of a Nicol prism. Discuss how Nicol prism can be used for the production and analysis of plane polarized light? Mention its limitations. The x and y components of the electric field are given by the following equations:

(i) $E_x = E_o cos\,(\omega t - kz),\ E_y = 0$;

(ii) $E_x = E_o cos\ (\omega t - kz),\quad E_y = E_o\ cos\,(\omega t - kz - \frac{\pi}{2})$;

(iii) $E_x = E_o\ cos\ (\omega t + kz),\ E_y = \frac{E_o}{\sqrt{2}} cos\,(\omega t + kz + \frac{\pi}{2})$;

(iv) $E_x = E_o\ cos\ (\omega t - kz),\quad E_y = \frac{E_o}{\sqrt{2}}(\omega t + kz)$. (a) Discuss the state of polarization, and (b) What will be the result of superposition of (i) and (ii)

Value of Constants:

$$\varepsilon_o = 8.85 \times 10^{-12}\ F/m$$

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

$$\mu_o = 4\pi \times 10^{-7}\ H/m$$