[This question paper contains 4 printed pages.]

Sr. No. of Question Paper : **2912** Roll No .....

Unique Paper Code : **2222514801**

Name of the Paper : Electromagnetic Theory (**DSC**)

Name of the Course : B.Sc. Prog.–Physical Sciences _NEP: UGCF-2022

Semester : **VIII**

Duration : **3 Hours** Maximum Marks: **90**

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 five questions.
4. Use of non-programmable scientific calculator is allowed.

1. Attempt any **six** questions: $(3 \times 6 = 18)$

(a) If the electric field intensity for an electromagnetic wave is expressed as $\vec{E} = 200 \sin(10^9 t)\ V/m$. Calculate the magnitude of displacement current density and conduction current density. Given: $\sigma = 4\ mho/m$ and $\varepsilon_r = 1$.

(b) Find the skin depth, if the frequency of a plane EM wave is 8×10^9 Hz and it propagates through a conductor with conductivity $\sigma = 5.8 \times 10^7$ S/m and $\mu_r = 1$.

(c) A parallel polarized wave propagates from air to a dielectric at Brewster angle of 60^o. Find the relative permittivity ε_r.

(d) A ray of light is incident normally from air to glass. Calculate the reflection and transmission coefficients.

(e) Distinguish between a left-handed and a right-handed circularly polarized light.

(f) Calculate the minimum thickness of calcite plate which would convert plane polarized light into circularly polarized light. Given: $\lambda = 8000$ A°, $n_o = 1.5533$ and $n_e = 1.5443$.

(g) Calculate the plasma frequency and minimum penetration depth for collision free plasma having 10^{12} electrons/m^3.

2. (a) State and prove the Poynting Theorem for electromagnetic fields for a generalized medium and give the physical meaning of each term. Explain that it is a representation of law of conservation of energy. (12)

(b) The average radiant power received by an area of 1 m^2 of earth surface is $1.35 \times 10^3\ Watt/m^2$. Calculate the r.m.s values of $\vec{E}$ and $\vec{H}$ in the sun's rays, assuming the rays to be monochromatic. (6)

3. (a) What is a *dilute plasma*? Obtain an expression for the electrical conductivity of ionized gases at low pressure and explain its physical significance. Hence, obtain an expression for its total current density. (12)

(b) A ray of light is incident on the surface of a glass plate of refractive index 1.5 at polarizing angle. Calculate the angle of refraction of the ray. (6)

4. (a) Derive Fresnel's relation for reflection and transmission of plane electromagnetic waves at an interface between two dielectric media when the electric field vector of the incident wave is perpendicular to the plane of incidence. Discuss the phase relationships of the reflected and refracted fields w.r.t. the incident field. (12)

(b) Explain the working of a Nicol prism. How it is used to analyze plane polarized light? (6)

5. (a) Deduce the following expression for Fresnel's formulae of wave normal in an anisotropic medium, symbols having their usual meaning within the context.

$$\frac{k_x^2}{v_p^2 - v_x^2} + \frac{k_y^2}{v_p^2 - v_y^2} + \frac{k_z^2}{v_p^2 - v_z^2} = 0$$

What is double refraction and how can it be explained in the light of the above expression?

(12)

(b) For calcite, the refractive indices of ordinary and extra ordinary rays are 1.65836 and 1.48641 at $\lambda_o = 5893$ 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?

(6)

6. (a) Starting from Maxwell's equations, obtain the eigen value equation for wave propagation through a symmetric planar optical waveguide having thickness of the core to be d and solve it for symmetric TE mode. Also, obtain an expression for wave guide parameter. What is its significance? (12)

(b) A symmetric planar dielectric waveguide of 5 μm thickness has a core of refractive index 1.53 and cover of refractive index 1.50. Calculate the maximum number of TE modes in the waveguide for free space wavelength $\lambda_o = 2\ \mu m$.

(6)

Value of constants:

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

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

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

$m_e = 9.1\text{x}10^{-31} kg$

$e = 1.6 \times 10^{-19} Coulomb$