RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, MAY 2023

SECOND YEAR [BATCH 2021-24]

Date : 23/05/2023 **PHYSICS [Honours]**

Time : 11 am – 1 pm **Paper : CC8** Full Marks : 50

Answer **any five** from the following questions: [5×10]

1. a) A plane electromagnetic wave with *p* polarization in the plane of incidence, falls obliquely on the interface between two simple dielectric media. Using the boundary conditions, derive the Fresnel formulae. Find the angle of incident for which there is not reflected ray $\left(\mu_1 = \mu_2 = \mu_0\right)$. 5+2

   b) Prove that the displacement current in the dielectric of a parallel plate capacitor is equal to the conduction current in the connection leads. 3

2. a) State and prove Poynting theorem relating the flow of energy at a point in space in an electromagnetic field. 1+5

   b) A plane electromagnetic wave travelling along positive *z* direction in an homogeneous dielectric medium with $\mu_r = 1$ and $\in_r = 4$ has a peak value of electric field intensity $6Vm^{-1}$. Estimate peak pointing vector. 4

3. a) Show that in a conductor the electric and the magnetic fields are not in phase and that the energy is not shared equally between the electric and magnetic field. 3+3

   b) Derive the Snell's law of refraction. 4

4. a) Obtain the boundary conditions satisfied by the electromagnetic field vector $\vec{E}$. 2

   b) The electric field in a plane monochromatic wave moving in free space is given by $\vec{E} = \left(2\hat{k} - 3\hat{j}\right) \times 10^{-3} \sin\left[10^7 \left(x + 2y + 3z\right) - \beta t\right]$. All numbers are in SI units. (i) What is the director of propagation? (ii) Check that whether it is a transverse wave. (iii) Find β and frequency ω. (iv) Find magnetic field $\vec{B}$. 1+1+2+2

   c) Calculate peak value of the electric field and magnetic field (*B*) in a microwave beam of intensity 100W/m^2 travelling in free space. 2

5. a) Find the expression for propagating vector of electromagnetic wave in dilute plasma. Show that the maximum penetration depth is given by $\delta_{\max} = \dfrac{c}{\omega_p}$ where ω_p is the plasma frequency. 4+3

   b) Show that the critical frequency for propagation of electromagnetic waves in plasma is given by $f_c = 9\sqrt{n}$, where *n* is the electron density. 3

6. a) Starting from Maxwell's equations $\vec{\nabla} \times \vec{E} = -\dfrac{\partial \vec{B}}{\partial t}$ and $\vec{\nabla} \times \vec{H} = \vec{J} + \dfrac{\partial \vec{D}}{\partial t}$ respectively, show that $\vec{\nabla}.\vec{B} = 0$ and $\vec{\nabla} \cdot \vec{D} = \rho$. 1+2

   b) Discuss why and how Ampere's circuital law was modified to include displacement current. 1+2

   c) Define a good and bad conductor from the point of view of the frequency of the incident electromagnetic wave. Why are metals opaque. 2+2

7. a) Degree of polarisation in reflected wave is defined as $\varphi = \dfrac{R_\perp - R_\parallel}{R_\perp + R_\parallel}$, where symbols carry their usual meanings. Calculate the degree of polarisation for ordinary light reflected from flint glass of refraction index 1.68. 4

b) Find the critical angle and Breastar angle for diamond. The speed of light in diamond is $1.25\times10^{8}\ m/s$. 3

c) Draw picture of wave front for ordinary and Extra-ordinary ray and show in that picture about the orientation of $\vec{E},\vec{D},\vec{S}$ and $\vec{K}$ - vectors. 3

8. a) What do you mean by Quarter wave plate and half wave plate? Determine the exact values of the thickness of such plates it they are constructed for 560 nm. It is given the order of thickness 10 to 30 μm. n_0 = 1.533 and n_e = 1.5443 for that crystal. 2+2+2

b) How can an elliptically polarised light be generated from a linearly polarised light? 2

c) A left circularly polarised beam $\left(\lambda_0 = 5893\,\mathring{A}\right)$ is incident on a quartz crystal (with optic axis cut parallel to the surface) of thickness 0.025 mm. Determine the state of polarisation of emergent beam. (n_e = 1.5533, n_0 = 1.5442). 2

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