RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, MAY 2024

SECOND YEAR [BATCH 2022-25]

Date : 18/05/2024 **PHYSICS [Honours]**

Time : 11 am – 1 pm **Paper : CC 8** Full Marks : 50

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

1. a) Find the ratio of the amplitudes of the conduction current and displacement current.
   b) What is evanescent wave, deduce the expression for evanescent wave and show that net energy flow through the surface into second medium is zero.
   c) Calculate the thickness of plate which would convert plane polarised into circularly polarised light. Given $\lambda = 589nm, n_o = 1.658, n_e = 1.486.$ [3+(1+3+1)+2]

2. a) Explain the propagation of electromagnetic waves in an isotropic dielectric medium. Show that waves are of transverse in nature. Show that the wave energy is equally shared between electric and magnetic fields.
   b) The electromagnetic waves, from air media of refractive index 1, are incident normally on a metal surface (non-magnetic) of refractive index $n_1 + jn_2$. Show that the ratio of the reflected intensity to incident intensity is $R = \dfrac{n_1^2 + n_2^2 - 2n_1 + 1}{n_1^2 + n_2^2 + 2n_1 + 1}$. [(2+3+1)+4]

3. a) What do you mean by s polarisation and p polarisation for an electromagnetic wave incident at the interface between two media. Clearly write down the equations followed by components of $\vec{E}$ and $\vec{H}$ vector in each case along with the boundary conditions.
   b) Show that the phase difference between electric field $\vec{E}$ and magnetic field $\vec{H}$ in a perfect conductor is 45^o. [(2+2+2)+4]

4. a) Deduce the reflection and transmission coefficients for an electromagnetic wave indicident of the interface of two media (non conducting and non magnetic) perpendicularly.
   b) Show that in a harmonically varying electromagnetic field represented by complex notations $\left(\vec{E} = \vec{E}_0 e^{-j\omega t} and\ \vec{H} = \vec{H}_0 e^{-j\omega t}\right)$, the time varying Poynting vector can be represented by real part of $\frac{1}{2}\left(\vec{E} \times \vec{H}^*\right)$, where H^* is the complex conjugate of $\vec{H}$. [6+4]

5. a) Expressing the inhomogeneous wave equations in terms of electromagnetic potentials $\vec{A}$ and ϕ obtain the Lorentz condition or Lorentz gauge.
   b) What do you mean by O-ray and E-ray in a birefractive medium. Discuss the characteristics and differences between positive and negative crystal in the regard. [4+(2+4)]

6. a) Show that by superposition of two plane electromagnetic waves a circularly or elliptically polarized light can be produced.
   b) "Ampere's circuital law for steady current was modified by introducing the displacement current". Derive the expression for displacement current.
   c) The rotations in the plane of polarisation at wavelength 589.3 nm in a certain substance in 10^o/cm. Calculate the difference between the refractive indices for right and left circularly polarised light in the medium. Derive the equation that you use. [3+3+(1+3)]

7. a) What is optic axis? Find the relation between ray refractive index and wave refractive index.
   b) The inner and outer conductors of a coaxial cable has radii a and b respectively. In the cable $\vec{E} = \frac{V_p \sin \omega t}{r \ln\left(\frac{b}{a}\right)} \hat{r}$ and $\vec{H} = \frac{I_p \sin \omega t}{2\pi r} \hat{\phi}$. Find the time average of power flow in the cable.
   c) What do you mean by skin depth? Show its dependence with the frequency of the incoming electromagnetic wave. [(1+3)+3+(1+2)]

8. a) Using Poynting theorem given below
   $$-\frac{dU_{em}}{dt} = \oint_A \vec{S}.d\vec{A} + P \ ,$$
   show that the law of conservation of energy for electromagnetic field in non-conducting medium is $\frac{\partial u}{\partial t} + \vec{\nabla}.\vec{S} = 0$ (where the symbols have usual meaning).
   b) A 20 cm length of a certain solution causes right-handed rotation of 40^o and 30 cm of another solution causes left-handed rotation of 24^o. What will be the optical rotation produced by 30 cm length of the mixture of the above solutions in the ratio 1:2 by volume?
   c) After full rotation of a polaroid the intensity of the electromagnetic wave remains unaltered. The wave may be unpolarised or may be circularly polarized one. How can you identify these two possibilities. [4+2+4]

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