2023

PHYSICS — HONOURS

Paper : CC-11

[Electromagnetic Theory]

Full Marks : 50

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***question no.*** **1** and ***any four*** questions from the rest.

1. Answer ***any five*** questions : 2×5

(a) Calculate the intrinsic impedance for a plane wave in the linear isotropic medium for which relative permittivity and relative permeability are 3 and 2 respectively.

(b) The dielectric constant of sea water is 85 at a frequency 350 MHz. If its resistivity is 0.25 Ω-m, find the ratio of conduction current to displacement current.

(c) Show that $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ is consistent with the absence of magnetic monopoles.

(d) The components of electric and magnetic vectors of an electromagnetic field are expressed as $E_y = E_0 e^{i(kx-\omega t+\alpha)}$, $B_z = B_0 e^{i(kx-\omega t)}$ respectively. Obtain the value of α, when $0 \le \alpha < 2\pi$.

(e) When the angle of incidence on a certain material is 60°, the reflected light is completely polarized. Find the refractive index for the material and also the angle of refraction.

(f) A certain length of 5% solution causes the optical rotation of 20°. How much length of 10% solution of the same substance will cause 35° rotation?

(g) Show that the specific rotation of an optically active substance is $s = \frac{\theta}{lc}$, where symbols have their usual meanings.

2. (a) State and prove Poynting theorem.

(b) Find the values of electric and magnetic fields on the surface of a wire carrying a current 'i'. The length and radius of the wire are 'L' and 'a' respectively. Also show that the Poynting theorem is satisfied. (1+3)+(2+2+2)

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3. (a) Show that without Maxwell's correction to Ampere's law, the continuity equation $\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{j} = 0$ is not valid.

   (b) An electromagnetic wave is incident at the interface of two linear-homogeneous dielectrics. Write down the boundary conditions at the surface. Find out reflection and transmission coefficients for oblique incidence, when the electric field is in the plane of incidence.

   (c) Find out the condition under which there is a phase reversal of the reflected wave. 2+(2+4)+2

4. (a) Show that the electric and magnetic fields are not in phase for electromagnetic wave propagating in a conducting medium.

   (b) What is meant by skin effect? Derive the expression for skin depth when an electromagnetic wave enters into a good conductor.

   (c) What is wave impedance? Show that wave impedance in free space is 120 $\pi\Omega$. 3+(1+3)+(1+2)

5. (a) State and explain Brewster's law.

   (b) Determine the angle of refraction and Brewster's angle if the refractive index of the medium is 1.41.

   (c) What do you understand by rotatory polarization? Give Fresnel's explanation of optical rotation. (2+2)+(1+1)+(1+3)

6. (a) What are uniaxial and biaxial crystals?

   (b) What do you understand by double refraction?

   (c) Deduce the speeds of o-ray and e-ray in calcite (i) in a plane perpendicular to the optic axis and (ii) along the optic axis. Hence, find the relative phase difference between the rays for light of wavelength 6000 Å in travelling a distance of 3×10^{-3} cm at right angles to the optic axis. [Given that $n_o = 1.658$ and $n_e = 1.486$]. 2+2+(2+2+2)

7. (a) What is retardation plate? Show that the thickness of the quarter wave plate $d = \frac{\lambda}{4(\mu_O - \mu_E)}$, where

   λ = wavelength of light, μ_O = r.i. of the medium w.r.t. O-ray

   μ_E = r.i. of the medium w.r.t. E-ray.

   (b) Calculate the thickness of the quarter wave plate for light of wavelength 5893 Å, given refractive indices for ordinary ray and extraordinary ray are 1.544 and 1.553 respectively.

   (c) Compute the thickness of a half wave plate for sodium light, given $n_o = 1.54$ and the ratio of the velocity of o-ray and e-ray is 1.007. Is the crystal positive or negative? (1+3)+3+(2+1)
