

Ref. No.: Ex/SC/PHY/UG/CORE/TH/13/2024(S)
B.Sc. Physics (Hons.) Special Supplementary Examination 2024
(3rd Year, 2nd Semester)
Subject: ELECTROMAGNETIC THEORY
PAPER-CORE 13

Time: 2 Hours

Full Marks: 40

Answer one question from each group. Symbols used have their usual meanings.

Group - A (CO - 1)

1. (a) State Poynting's theorem. Write down the differential form of Poynting's theorem. Explain how it implies the conservation of energy. What is the unit of Poynting vector?
(b) Write down the significance of 'displacement current'.

(2 + 2 + 2 + 1) + 3

2. (a) Derive wave equation for electromagnetic wave in free space from Maxwell's equations. Show that electromagnetic wave is transverse in nature.
(b) Find out the expression for energy density and intensity of an electromagnetic wave propagating in free space.

(2 + 4) + 4

Group - B (CO - 2)

3. (a) For electromagnetic wave propagation through a conducting medium, find out the expression for skin depth. Is it a characteristic parameter of the conducting medium? Explain.
(b) Show that for poor conductor the skin depth is independent of frequency of propagating wave.

(5 + 2) + 3

4. (a) Establish the boundary conditions that are followed by the components of the electric field vector ($\vec{E}$) at the interface of two media.
(b) Derive the expressions for reflection and transmission coefficients for s -polarized wave.

4 + 6

Group - C (CO - 3)

5. (a) What is double refraction? What are o-ray and e-ray?
(b) Explain how the state of polarisation of an EM wave may be explained by considering the superposition of two mutually perpendicular oscillations.
(c) The x and y components of an electric field are given by
 $E_x = \frac{1}{2} \cos\left(\omega t - kz - \frac{\pi}{4}\right)$; $E_y = \frac{\sqrt{3}}{2} \cos(\omega t - kz)$
Explain the state of polarization.

(2 + 2) + 3 + 3

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6. (a) Define Brewster's angle with a clear diagram. If the angle of incidence of a light beam falling on a glass plate (refractive index = 1.5) through a certain liquid is 48.4° , then the reflected light is found to be linearly polarized. Find out the refractive index of the liquid.
 (b) Establish the expression of the thickness of a half-wave plate using the phenomenon of interference between o-ray and e-ray. (2 + 2) + 6

Group - D (CO - 4)

7. (a) For TE_{mn} modes of wave propagation through rectangular waveguide, prove that at least one of the indices must be nonzero. Find out the expression for cut-off frequency.
 (b) For a given rectangular waveguide of dimension $2.28 \text{ cm} \times 1.01 \text{ cm}$, Find out the lowest cut-off frequency for TE_{10} mode. (6 + 2) + 2
8. (a) Show that TEM mode of electromagnetic wave cannot exist in a hollow wave guide.
 (b) What do you mean by Numerical Aperture and Acceptance angle of an optical fiber? 6 + (2 + 2)