3 (Sem–6/CBCS) PHY HC 1

2024

PHYSICS

(Honours Core)

Paper : PHY–HC–6016

(Electromagnetic Theory)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×7=7

   (a) How does skin depth affect conductivity of a good conductor ?

   (b) What is the physical significance of equation of continuity ?

(c) What will be the value of Poynting vector in an evanescent field?

(d) What is a quarter-wave plate?

(e) Which substances are called dextrorotatory?

(f) What do you mean by an anisotropic medium?

(g) Write the expression for guided wave length.

2. Answer the following questions: 2×4=8

(a) Write *one* important difference between uniaxial and biaxial crystals. Give examples.

(b) Calculate the Poynting vector at the surface of the sun, given that the power radiated by the sun is 3.8×10^{26} watt and radius of the sun is 7×10^{8} *m*.

(c) Find the refractive index of *(i)* paraffin with $\mu_r = 1$, $\varepsilon_r = 2.1$; and *(ii)* distilled water with $\mu_r = 1$, $\varepsilon_r = 81$.

(d) Find the expression of electric field in terms of scalar and vector potentials.

3. Answer ***any three*** questions: 5×3=15

(a) What is Brewster's angle? Draw a neat diagram. An incident wave along $\left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j}\right)$ falls on a refractive surface at $Z = 0$. If the refractive index is $\mu = \sqrt{3}$, find the propagation vectors for the reflected and the refracted rays. 1+2+2=5

(b) What do you understand by plasma and plasma oscillation frequency? Show that in plasma electric current lags the electric field by $\frac{\pi}{2}$. 2+3=5

(c) When light wave passes through anisotropic crystal, set the *three* equations of electric field in terms of propagation vectors and *three* principal indices of refraction.

(d) A light wave linearly polarized in the plane of incidence, is incident at an angle 30° on a glass plate of refractive index 1.52 in air. Assuming zero absorption, calculate reflection and transmission coefficients.

(e) An unpolarized plane wave of intensity $10\ mW/cm^2$ passes through two nicols with their principal plane section at 30° to each other. Calculate the intensity of doubly transmitted waves.

4. Answer ***any three*** of the following questions : 10×3=30

(a) Consider the propagation of an electromagnetic wave from one medium to another. Draw a neat diagram showing the incident, reflected and transmitted waves with properly denoting the direction of electric field, magnetic field and the propagation vector considering the electric field vector parallel to the plane of incidence. Derive the expression

$$r_{11} = \frac{tan(\theta_I - \theta_T)}{tan(\theta_I + \theta_T)}$$

and show that at grazing angle a glass plate can act as a mirror. 4+(5+1)=10

(b) What are 'electromagnetic potentials'? Show that $E = -\nabla\phi - \frac{\partial A}{\partial t}$. Discuss about the gauge transformation. Write the expression for Lorentz gauge. 2+4+3+1=10

(c) Show that for a conducting medium the propagation vector is complex in nature. What do the real and imginary parts of the propagation vector signify? Write the expression for electric and magnetic field vectors of a plane electromagnetic wave propagating in conducting medium along Z direction. Derive the expression for skin depth. 4+2+2+2=10

(d) Find the numerical aperture for a step index optical fibre. Mention *two* differences between step and graded index (GRIN) fibres. What are single mode and multimode fibres? 5+2+3=10

(e) Describe the construction and working principle of Lorentz half-shade polarimeter. What is specific rotation of a solution? (3+4)+3=10

(f) How will you produce polarized light circularly and elliptically? How may Babinet's compensator be used to analyse the above mentioned polarized light? Use ray diagram to explain the above. 3+3+4=10
