Total number of printed pages–7

1 (Sem–5/FYUGP) PHY04MJ

2025

PHYSICS

(Major)

Paper : PHY0500404

(Electromagnetic Theory)

Full Marks : 45

Time : 2 hours

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

1. Answer the following questions : 1×5=5

   (a) What is displacement current?

   (b) Define skin depth.

   (c) What is a waveguide?

(d) Give examples of uniaxial and biaxial crystals.

(e) What is the role of cladding in optical fibre ?

2. Answer ***any five*** of the following questions : 2×5=10

(a) Write Lorentz gauge condition. What is its advantage ?

(b) What do you mean by a pointing vector and what does it represents ?

(c) Write the electromagnetic wave equation in free space governing the time varying electromagnetic field vectors $\vec{E}$ and $\vec{H}$.

(d) What are the boundary condition for electric field $\vec{E}$ and magnetic field $\vec{H}$ at the interface between two media ?

(e) An electromagnetic wave is incident on the surface of water normally. Find the percentage of incident intensity transmitted into water. Given the refractive index of water is 1·33.

(f) How will you distinguish between quarter wave plate and half-wave plate ?

(g) Determine the numerical aperture of an optical fibre when the core and cladding refractive indices are 1·51 and 1·47 respectively.

(h) Explain the term optical rotation.

(i) Find the thickness of a quarter wave plate of quartz for light of wavelength 6000Å. Given the refractive indices of quartz for *E*-ray and *O*-ray are 1·5533 and 1·5442 respectively.

(j) Write the parameters on which the reflection and refraction of electromagnetic waves depends.

3. Answer ***any four*** of the following questions : 5×4=20

(a) What is gauge transformation ? Show that electric and magnetic field vector $\vec{E}$ and $\vec{B}$ are invariant under gauge transformation. 1+2+2=5

(b) Obtain Pointing theorem for the conservation of energy in an electromagnetic field and discuss the physical meaning of each term in the resulting equation. 3+2=5

(c) Assuming that the electric vector of an electromagnetic wave given by $E = E_0 e^{i(\vec{k}.\vec{r}-wt)}$ and in crossing a boundary the tangential component of electric intensity is continuous, prove the various laws of reflection and refraction.

(d) Explain the Brewster's law with the help of Fresnel's formula.

(e) Find the reflection co-efficient if angle of incidence is 60° of e.m. wave travelling from free space (medium 1) to a dielectric (medium 2) with $\varepsilon_2 = 4\varepsilon_0$ and $\mu = \mu_0$ in case of perpendicular polarisation.

(f) What is Nicol prism ? Explain its action as polariser and analyser. 1+4=5

(g) Define specific rotation. Write its unit. A tube of sugar solution 20*cm* long is placed between crossed Nicols and illuminated with light of wavelength 6000*Å*. If the optical rotation produced is 13° and the specific rotation is 65°, determine the strength of solution.

1+1+3=5

(h) What is an optical fibre? On which principle it works? Distinguish between step index fibre and graded index fibre. 1+1+3=5

4. Answer ***any one*** of the following questions : 10

(a) Write down the Maxwell's four electromagnetic field equations. Define magnetic vector and scalar potential. Deduce Maxwell's field equations in terms of magnetic vector and scalar potential. 2+3+5=10

(b) Discuss the propagation of plane electromagnetic wave in a conducting media. Hence find the expression for phase velocity and depth of penetration. 6+2+2=10

(c) Describe the construction and principle of a Laurent's half-shade polarimeter. How will you use it to find *(i)* Specific rotation *(ii)* Strength of Sugar solution. 7+2+1=10

(d) Write short notes on the following : 5×2=10
(any two)

(i) Double refraction

(ii) Babinet compensator

(iii) Rectangular waveguide

(iv) Phase retardation plates