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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 : $1 \times 5 = 5$
- (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 $6000\text{\AA}$. 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 Poynting 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

$$E = E_0 e^{i(\vec{k} \cdot \vec{r} - \omega t)}$$

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 $\epsilon_2 = 4\epsilon_0$ 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 20cm long is placed between crossed Nicols and illuminated with light of wavelength $6000\text{\AA}$. 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 :
(any two) 5×2=10

- (i) Double refraction
 - (ii) Babinet compensator
 - (iii) Rectangular waveguide
 - (iv) Phase retardation plates
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