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**3 (Sem-6/CBCS) PHY HC 1**

**2023**

**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 ***all the seven*** questions :  $1 \times 7 = 7$
- (a) What do you mean by isotropic medium ?
  - (b) What is a half wave plate ?
  - (c) Write the expression for Lorentz gauge.
  - (d) How is refractive index related with dielectric constant ?
  - (e) Write momentum of a photon in terms of its frequency.
  - (f) Write down the intrinsic impedance for free space.

*Contd.*



(g) What is cladding in di-electric waveguide ?

2. Answer the following questions :  $2 \times 4 = 8$

(a) What is Nicol prism ? Draw a neat diagram of it.

(b) Find numerical aperture of a step index fibre.

(c) Calculate the Skin depth for an EM wave of frequency 100 MHz in copper. Given, conductivity for

$$\sigma_{Cu} = 6.25 \times 10^7 \text{ mho/m and}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ henry/meter}$$

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

3. Answer **any three** questions :  $5 \times 3 = 15$

(a) Using the concept of displacement current density, derive the expression for EM wave in free space.

(b) Show that EM waves are transverse in nature.

(c) How will you use Babinet's compensator to analyse polarisation of light ?

(d) Explain the terms Levo-rotatory and Dextro-rotatory. A 15 cm tube containing sugar solution of sp. rotation  $66^\circ$  shows optical rotation  $7^\circ$ . Find strength of the solution.  $1+1+3=5$

(e) What is a dielectric waveguide ? Find the condition of internal reflection at the two boundaries of the waveguide.  $2+3=5$

4. Answer **any three** of the following :  $10 \times 3 = 30$

(a) Derive the expression for EM energy flux coming out of a surface. What is the significance of Poynting vector ?  $8+2=10$

(b) (i) Derive the expression for total internal reflection using EM wave equation where  $\vec{E}$  is parallel to the plane of incidence.

(ii) An EM wave in free space has electric field given by

$$\vec{E} = 20 \cos(3y + 4z - 0.5ct) \hat{i}.$$

What is its propagation vector ?

Given  $c = 3 \times 10^8 \text{ m/sec}$ .  $8+2=10$



- (c) Using Fresnel equations, show that the amplitude reflection coefficient for  $\vec{E}$  parallel to the plane of incidence is equal to zero if sum of angle of incidence and polarising angle is  $\pi/2$  and hence derive Brewster's law. Also sketch the variation of amplitude reflection co-efficients for both perpendicular and parallel components of  $\vec{E}$ . 3+4+3=10

- (d) What is meant by rotatory polarisation? Describe the theory and working of Laurent's half-shade polarimeter. 2+3+5=10

- (e) Equations of two electric field vectors oscillating in perpendicular direction are given by  $\vec{E}_1 = \hat{i} a_1 \cos(kz - \omega t)$  and  $\vec{E}_2 = \hat{j} a_2 \cos(kz - \omega t + \theta)$ , assuming time variation of the resultant field at  $z=0$ , find the state of polarisation (SOP) of the resultant at different values of  $\theta$ .

- (f) Using Maxwell's equation, derive the Fresnel's wave equation in anisotropic medium.