2020

PHYSICS

Paper : PHY CC 13

(Electromagnetic Theory)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. *(a)* Propagation constant in a conducting medium is complex in nature. What does it signify? 1

(b) What is wave impedance? 1

(c) Define numerical aperture in case of optical fiber. 1

(d) Write the expression for plane wave solution of electric field vector E for an electromagnetic wave. 1

(e) What is the cut-of frequency of a rectangular wave guide? 1

2. *(a)* Write Maxwell's equation in integral form. What is the significance of displacement current? 1+1=2

(b) Calculate the refractive index of glass if the light of wavelength 540 nm is plane polarized when reflected at an angle 60°. 2

(c) An electromagnetic wave is entering to a medium A having permittivity ε_2 and permeability μ_2 from another medium B having permittivity ε_1 and permeability μ_1. What will be the refractive index of the medium A with respect to medium B? 2

(d) Define left and right circularly polarized light. 2

(e) A step index fiber has a core of refractive index 1·55 and a cladding of refractive index 1·53. Determine its numerical aperture and acceptance of angle if the surrounding medium is air. 2

3. Answer any *five* of the following questions :

(a) Define attenuation coefficient of a conducting medium. How is skin depth related to it? Considering the medium to be non-magnetic, calculate the skin depth for an EM wave of frequency 100 MHz in copper. Given conductivity (σ) for Cu $= 6{\cdot}25 \times 10^7$ mho/m and $\mu_0 = 4\pi \times 10^{-7}$ H/m. 1+1+3=5

(b) Derive the boundary condition for D vector at the interface of two different media. 5

(c) Define isotropic dielectric medium and dielectric constant. Assuming that the conductivity, permeability and permittivity of a medium do not change with frequency, does the medium with $\sigma = 0{\cdot}1$ mho, $\mu_r = 1$, $\varepsilon_r = 40$, behave like a conductor or a dielectric at *(i)* 50 kHz and *(ii)* 10 GHz? 1+1+3=5

(d) Prove that when angle of incidence corresponds to the Brewster's angle, the reflected and refracted rays are at right angles to each other. 5

(e) Mention the basic criteria of constructing a dielectric waveguide. Show that group velocity of a guided wave can be expressed as

$$v_g = \frac{c}{n + \omega \frac{dn}{d\omega}}$$

where c = velocity of light, n = refractive index and ω = angular velocity. 1+4=5

(f) Draw a schematic diagram of Laurent half-shade polarimeter and describe how specific rotation of an optically active liquid can be found out using the polarimeter. 2+3=5

(g) An EM wave travels in free space with the electric field component

$$E = 100 e^{j(0{\cdot}866y + 0{\cdot}5z)} \hat{x} \text{ V/m}$$

Determine *(i)* ω and *(ii)* the magnetic field component. 2+3=5

4. Answer any *two* of the following questions :

(a) Derive Poynting's theorem. What is the significance of Poynting vector? 8+2=10

(b) Describe the construction and action of Babinet compensator. How can it be used to produce elliptically and circularly polarized light? 4+4+2=10

(c) Derive Fresnel's equation for electromagnetic wave with E vector polarized parallel to the plane of incidence. Using Fresnel's equation, show that no reflection occurs between two media having same refractive index. 8+2=10

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