This question paper contains 4+2 printed pages]

Your Roll No. .....

1228

B.Sc. (Hons.)/III **A**

PHYSICS—Paper XVIII

(Electromagnetic Theory)

Time : 3 *Hours* *Maximum Marks* : 38

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *All* questions.

1. Attempt any *five* of the following :

   (*a*) Calculate the plasma frequency and maximum penetration depth for a plasma containing 10^{12} electrons/m^3.

   (*b*) Calculate the minimum thickness of a calcite plate, which would convert plane polarized light of wavelength 5960 Å, into circularly polarized light, given n_0 = 1.568 and n_e = 1.486.

P.T.O.

(*c*) Calculate the skin depth for a conductor at 1 GHz, given that $\sigma = 3.8 \times 10^7$ mho/m, $\mu = 2.57 \times 10^{-7}$ henry/m.

(*d*) Give potential formulation in electrodynamics. Express Maxwell's equations in free space in terms of scalar and vector potentials.

(*e*) In a medium characterized by $\sigma = 0$, $\mu = \mu_0$ and $\epsilon = 4\,\epsilon_0$, the electric field is :

$$\overline{\mathrm{E}} = 20 \sin (10^8 t - kz)\, \hat{j}\ \mathrm{V/m}$$

Determine :

(*i*) $\overline{k}$, wave-number

(*ii*) $\overline{\mathrm{H}}$.

(*f*) Show that a rectangular wave guide does not support TM_{10} and TM_{01} modes.

(*g*) In a material for which $\sigma = 5\ (\Omega m)^{-1}$, and $\epsilon_r = 1$, the electric field intensity is :

$$\bar{E} = 250 \sin (10^{10} t)\ V/m.$$

Find the conduction and displacement current densities and the frequency at which they have equal magnitudes.

(*h*) If a parallel polarized e.m. wave is incident from air onto distilled water with $\mu_r = 1$, $\epsilon_r = 81$, find the Brewster angle θ_{iB}. 5×2

2. (*a*) Show how Maxwell modified Ampere's law to make it consistent with the equation of continuity. Explain the significance of term "Displacement Current". 4

(*b*) Show how you would derive the Maxwell's divergence equations from the Maxwell's Curl equations. 3

Or

(*a*) Discuss and compare Lorentz and Coulomb gauges. Show that Lorentz transformation remains invariant, if the gauge function ϕ satisfies the differential equation :

$$\nabla^2\phi - \epsilon\mu\frac{d^2\phi}{dt^2} = 0. \qquad 4$$

(*b*) Obtain an expression for the characteristic impedance of a dielectric medium for propagation of e.m. wave through it. How is it related to the characteristic impedance of free space ? 3

3. (*a*) Derive Fresnel's relations for reflection and refraction of plane e.m. waves at an interface between two dielectric media when the electric field vector of the incident wave is normal to the plane of incidence. 4

(*b*) Deduce the laws of reflection and refraction starting from the boundary conditions satisfied by e.m. fields at an interface between two media. 3

Or

(*a*) What do you understand by plasma ? Obtain an expression for plasma oscillation frequency. 4

(*b*) Show that in plasma, electron current lags the electric field by $\pi/2$. 3

4. (*a*) In what respect does an electrically anisotropic medium differ from an isotropic medium ? Write the expression for the permittivity tensor and comment on its nature. 3

(*b*) Show that in an anisotropic medium the direction of energy flow is different from wave propagation. 4

Or

(*a*) Distinguish between positive and negative uniaxial crystals giving *one* example of each. Also draw their wavefront diagrams. 4

(*b*) How would you optically distinguish between a half wave plate and a quarter wave plate ? 3

5. (*a*) What is a cavity resonator ? Find the electric and magnetic field components for the TE mode in a rectangular resonant cavity. 5

(*b*) An air filled cubical cavity operates at a resonant frequency of 2 GHz when excited at the TE_{101} mode. Determine the dimensions of the cavity. 2

Or

(*a*) What is the physical parameter that governs the light gatterning power of an optical fibre ? Obtain an expression for this parameter in terms of the indices of refraction of the core and the cladding. 2

(*b*) Explain pulse dispersion in a step index optical fibre. How is it reduced in a graded index fibre ? 3

(*c*) An optical fibre has a core of refrative index 1.48 and a cladding of refractive index 1.46. Calculate the acceptance angle and the numerical aperture of the fibre. 2