सर्वं विघ्नमानम्

WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2023

PHSACOR13T-PHYSICS (CC13)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Question No. 1 is compulsory and any *two* questions from the rest

1. Answer any ***ten*** questions from the following: $2\times10=20$

(a) Calculate the skin depth for radio waves of wavelength 3 m (in free space) in copper, the electrical conductivity of which is 6×10^7 s/m.

(b) Find the refractive index of glass, if the Brewster angle for light of a given wavelength be 60°. Find the corresponding angle of refraction.

(c) What are the special properties of quartz that make it suitable for use as optical fibre material?

(d) Show that for a waveguide propagation. $v_g v_p = c^2$ where v_g, v_p and c stand for group velocity, phase velocity and speed of light in free space respectively.

(e) What do you mean by TE, TM and TEM waves?

(f) Define optic axis of a crystal.

(g) The terms 'poor' and 'good' conductor depend on frequency — Explain.

(h) The magnetic intensity in a region of free space is given by $\vec{H} = H_0\hat{y}\cos\omega(t-z/c)$, where '$c$' is the speed of light. What is the displacement current density if there is no free charge?

(i) How one can get plane polarized light using double refraction in a crystal?

(j) State and explain Malus's law.

(k) What do you mean by electromagnetic momentum density? What is its unit?

(l) For water-air interface, the refractive index of water is 1.33 for visible light and 9.0 for radio waves. Compare the reflectance in the two cases.

(m) Show that in a conductor, the electric and magnetic fields are not in phase.

(n) What is Brewster's angle?

2. (a) For a linear medium with $\vec{B} = \mu\vec{H}$ and $\vec{D} = \varepsilon\vec{E}$, show that 5

$$\vec{\nabla}\cdot(\vec{E}\times\vec{H}) = -\frac{1}{2}\frac{\partial}{\partial t}(\vec{E}\cdot\vec{D} + \vec{B}\cdot\vec{H}) - \vec{J}\cdot\vec{E},$$

where the symbols stand for the standard notations of electromagnetic theory.

(b) Find the reflectance and transmittance of a plane electromagnetic wave incident normally from air on a dielectric surface of refractive index 1.4. 2

(c) Consider that the electric field vectors of two electromagnetic waves propagating in the z-direction in free space are $\vec{E}_1 = \hat{i}E_0\cos(kz-\omega t) + \hat{j}E_0\sin(kz-\omega t)$ and $\vec{E}_2 = \hat{i}E_0\sin(kz-\omega t) + \hat{j}E_0\cos(kz-\omega t)$. Determine the state of polarization of the wave resulting from the superposition of these two waves. 3

3. (a) "In the microwave region, the surface of a pure and that of a silver coated brass wave-guide appears identical" — Explain. 2

(b) A rectangular air-filled copper wave guide with dimension as 2 cm width, 1 cm height and 30 cm length is operated at 9 GHz with dominant mode. Find the cutoff frequency, guide wavelength and phase velocity. 1+1+2

(c) A 30 cm long tube containing sugar solution shows a rotation of $\pi/6$ of the plane of vibration of a plane polarized light. Find the strength of the solution. Given the specific rotation of sugar is equal to 66.5 $dm^{-1}g^{-1}cm^{-3}$. 2

(d) What do you mean by O-ray and E-ray? 2

4. (a) Show how Maxwell's equations in free space imply local conservation of charge (continuity equation). 3

(b) Show that under a gauge transformation of the vector and scalar potential, $\vec{A}$ and ϕ, the electromagnetic field vectors are invariant. 3

(c) Briefly describe the working principle of a Babinet Compensator. 4

5. (a) A plane electromagnetic wave is incident obliquely on a boundary between media of different electric and magnetic properties. Derive Fresnel's formula. What is the phase change of the reflected wave when there is no transmission? 4+2

(b) A step index fibre has a core of refractive index 1.55 and a cladding of refractive index 1.53. Determine its numerical aperture and acceptance angle. 2

(c) A plane EM wave with $\vec{B} = 3\times10^{-6}$ T and travelling in vacuum falls normally on a surface and is totally reflected. Calculate the pressure exerted on the surface. 2

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