'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 6th Semester Examination, 2023

CC13-PHYSICS

ELECTROMAGNETIC THEORY

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
All symbols are of usual significance.

GROUP-A

1. Answer any ***five*** questions of the following: 1×5 = 5

   (a) "When an electromagnetic wave is incident normally on the conducting surface then the electric field vector of the incident wave and that of the reflected wave are equal in magnitude but oppositely directed. Justify this statement.

   (b) What do you mean by optic axis in a double refracting crystal?

   (c) Calculate the frequency at which the skin depth in sea water is 1 m. Given $\sigma = 4.3$ mho m^{-1}, $\mu = 4\times10^{-7}$ Hm^{-1}

   (d) What is the refractive index of a piece of glass if the light of wavelength 5460 Å is plane polarised when reflected at an angle of 60º?

   (e) An unpolarised plane light wave of intensity 20 mW cm^{-2} passes through two Nicols with the principal section at 60º to each other. Calculate the intensity of transmitted wave.

   (f) Why electromagnetic wave is attenuated in conducting medium?

   (g) What percentage of light wave is reflected back when it is incident normally on an air glass interface (Refractive index of glass = 1.5)?

   (h) What is wave guide?

GROUP-B

Answer any *three* questions of the following 5×3 = 15

2. (a) What is the difference between conduction current and displacement current? 3

   (b) Explain how Maxwell modified the Ampere's law and introduced the concept of displacement current. 2

3. Show that $\vec{B} = \frac{1}{c}(\vec{n}\times\vec{E})$ for the propagation of plane electromagnetic wave in free space. ($\vec{n}$ is a unit vector in the direction of propagation and c is the speed of light in free space) 5

4. (a) The electric field associated with an electromagnetic wave in free space is given by $\vec{E} = \hat{x}\, E_0 \cos(kz - \omega t)$. Find the corresponding magnetic field $\vec{H}$. 2

   (b) What is meant by numerical aperture of an optical fibre? Obtain an expression for numerical aperture of a step index fibre. 3

5. Describe the construction and action of a Nicol prism as polariser and analyser. 5

6. (a) Describe the state of polarisation of wave represented by 3

$$\vec{E}(z,t) = \hat{i}\, E_0 \cos(kz - \omega t) - \hat{j}\, E_0 \sin(kz - \omega t)$$

   (b) What do you mean by positive and negative crystals? Explain with examples. 2

GROUP-C

Answer any *two* questions of the following $10 \times 2 = 20$

7. (a) Starting from Maxwell's equation derive the wave equation for electric and Magnetic field in dilute plasma. 3

   (b) Show that dilute plasma behaves like a medium of refractive index $n = \sqrt{1 - \frac{w_p^2}{w^2}}$, 4

   where w_p is plasma angular frequency and w is the angular frequency of electromagnetic wave.

   (c) Determine the skin depth in plasma. 3

8. (a) A plane electromagnetic wave, polarised perpendicular to the plane of incidence, is incident obliquely on the interface between two simple dielectric media. Using the boundary conditions obtain the expression for reflection and transmission co-efficients. 8

   (b) Calculate the strength of electric field at a distance of 10 m from a 60 W lamp. 2

9. (a) Briefly describe the construction and working of a Laurent half shade polarimeter explaining the action of half shade device. 6

   (b) How would you use it to determine the specific rotation of sugar solution? 2

   (c) 24 cm length of a solution with 5% concentration causes an optical rotation of 20º. How much length of 10% solution of the same substance will cause a rotation of 35º? 2

10. (a) Explain how can you convert a right handed circularly polarised light into a left handed circularly polarised light. 2

    (b) An optical fibre of core refractive index 1.6 has a diameter of $50\,\mu m$. Calculate the number of total internal reflections that a ray incident at 30º will suffer in moving through 1 m length of the fibre. 3

    (c) Show that in conducting medium electric field vector of electromagnetic wave is not in phase with magnetic field vector. 3

    (d) In a graded index fibre the radial distribution of index is given by $n(r) = 1.52 - 2r^2$ with r in mm. Upto a radius $r_0 = 0.2\,mm$. Calculate the acceptance angle of the fibre. 2

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