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Your Roll No. .....

B.Sc (Hons.)/III

E

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 **five** questions **in all. Question 1 is compulsory.***

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The use of non-programmable calculators is permitted.

1. Attempt any **five** parts:

a) Using Maxwell's equations show that the free space impedance is equal to 377 Ω.

b) Calculate the skin depth for silver at 60 GHz, given that $\sigma = 6 \times 10^7$ mho/m, $\mu = 3 \times 10^{-7}$ H/m.

c) If a parallel polarized electromagnetic wave is incident from air onto distilled water with $\mu_r = 1$, $\epsilon_r = 81$, find the Brewster angle.

d) In what respect does an electrically anisotropic medium differ from an isotropic medium? Write the expressions for the permittivity tensor and comment on its nature.

e) Give reasons as to why graded index optical fibre is better than a step index fibre.

f) Calculate the Numerical Aperture (NA) and acceptance angle for an optical fibre given that refractive indices of the core and the cladding are 1.49 and 1.46 respectively.

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g) Draw the wave surfaces for calcite and quartz crystals.

h) Calculate the cut-off frequency and cut off wavelength for the dominant TE mode in a rectangular waveguide of dimensions 1 cm × 2 cm.

(5 × 2)

2. (a) Define a linear homogeneous and isotropic medium. Starting from Maxwell's equations for electromagnetic field, obtain the wave equations for the electric and magnetic field vectors in a homogeneous and isotropic medium.

(5)

(b) Assuming plane wave solutions show that electromagnetic waves are transverse in nature. Write $\vec{H}$ in terms of $\vec{E}$.

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(2)

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3. (a) Show that Maxwell' s equations can be expressed as two coupled second order partial differential equations in terms of scalar and vector potentials. (5)

   (b) How do the above equations get simplified using Lorentz gauge? (2)

4. (a) Discuss the propagation of electromagnetic waves through dilute plasma. Obtain expressions for electrical conductivity, frequency and refractive index of plasma. (5)

   (b) Calculate plasma frequency for a plasma containing 10^{12} electrons/m^3. For such plasma, what is the penetration depth of the wave having frequency of 600 MHz. (2)

5. Starting from Maxwell's equations for a conducting medium, obtain expressions for skin depth, refractive index and phase difference between the electric and magnetic field vectors for a good conductor. (7)

6. (a) A plane electromagnetic wave with polarization parallel to the plane of incidence is incident at an angle θ on the interface between two dielectrics. Derive Fresnel's relations for reflection and transmission of the wave. (5)

   (b) Define Brewster's angle. Why is it called polarizing angle? (2)

7. (a) Derive Fresnel's equation for phase velocities for plane wave propagation in an anisotropic medium. How does this law lead to phenomenon of double refraction? (5)

   (b) Show that in an anisotropic medium energy is not propagated along the direction of wave propagation. (2)

8. (a) What is a cavity resonator? Derive expressions for electric and magnetic fields for the TE mode in a rectangular cavity bounded by perfectly conducting walls. (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)

Values of constants

$\epsilon_0 = 8.85 \times 10^{-12}$ F/m
$\mu_0 = 4\pi \times 10^{-7}$ H/m
$c = 3 \times 10^8$ m/s

Electron mass $= 9.11 \times 10^{-31}$ kg
Electron charge $= 1.602 \times 10^{-19}$ C