বিদ্যাসাগর বিশ্ববিদ্যালয়
VIDYASAGAR UNIVERSITY

Question Paper

B.Sc. Honours Examinations 2021
(Under CBCS Pattern)
Semester - VI
Subject: PHYSICS
Paper : C 13-T & P
Electromagnetic Theory

Full Marks : 60 (Theory-40 + Practical-20)
Time : 3 Hours

Candidates are required to give their answers in their own words as far as practicable.
The figures in the margin indicate full marks.

[Theory]

Group - A

Answer ***any two*** of the following: 2×15=30

1. (a) Write down the Maxwell's field equations with physical significance. (4)

   (b) Explain why and how Ampere's circuital law is modified to include displacement current. (3)

   (c) Show that the equation of continuity is contained in Maxwell's equations. (3)

(d) Give the physical significance of displacement current. (2)

(e) Consider a medium dielectric constant $\varepsilon_r = 80$ and conductivity $\sigma = 10^{-3}(\Omega - m)^{-1}$. Compare the value of conduction and displacement current densities at frequencies 100 Hz and 100 MHz. (3)

2. (a) Define 'skin depth'. Deduce the expression for 'skin depth' in case of propagation of electromagnetic waves through a conducting medium having permeability μ and permittivity ε. (1+5)

(b) The electric field intensity of a plane wave in air is given by

$\vec{E} = 4 \times 10^{-6} \times \cos(10^7 \pi t - kz)\hat{i} + 4 \times 10^{-6} \times \sin(10^7 \pi t - kz)\hat{j}\ V/m$. Find the values of k, corresponding magnetic field. (3)

(c) What is radiation pressure? (1)

(d) What is a quarter wave plate? (1)

(e) Discuss how a quarter wave plate can be used to produce circularly and elliptically polarized light. (4)

3. (a) What are the *s*-polarization and *p*-polarization of an electromagnetic wave? How the concept of Brewster's angle explained for *p*-polarized wave in specific conditions? (2+2)

(b) Show the variation in amplitude coefficients for *s*-polarized and *p*-polarized waves (going from air to glass) as a function of angle of incidence and explain. (2+2)

(c) The specific rotation of the quartz for λ = 508.6 nm is 29.73 deg/mm. Calculate the difference between the refractive indices for left and right circularly polarized light for quartz. (2)

(d) Explain the phenomenon of double refraction in a uniaxial crystal by Huygens' theory. (5)

4. (a) Calculate numerical aperture of an optical fibre. (4)

(b) A step index fibre has a core of refractive index 1.50 and a cladding of refractive index 1.40. If the fibre is used in a water environment, find its numerical aperture and the acceptance angle. Take the refractive index of water as 1.33. (2)

(c) What do you mean by a graded index fibre? Discuss its advantages over a step index fibre. (3)

(d) Show that normal component of electric displacement vector is not continuous at the boundary. (3)

(e) For transverse electric waves propagating along rectangular waveguide with perfectly conducting walls find expression for cut off wavelength. (3)

Group - B

Answer ***any one*** of the following: 1×10=10

5. (a) State and establish Poynting theorem in electromagnetism. (2+4)

(b) Explain the significance of Poynting vector. Find the dimension of Poynting vector. (1+1)

(c) The maximum value of the $\vec{E}$ field of an electromagnetic wave in free space is 1000 V/m. Find the maximum value of the $\vec{H}$ field of the wave. (2)

6. (a) Prove that $n^2 = 1 - \frac{\omega_p^2}{\omega^2}$ for e. m. wave moving with frequency ω in plasma. Where n is the refractive index, and ω_p is the plasma frequency. (7)

(b) Calculate the frequency at which the skin depth in sea water is 1 m. $\sigma = 4.3$ S/m and $\mu_0 = 4\pi \times 10^{-7}$ H/m (3)

[Practical]

Answer ***any one*** of the following: 1×20=20

1. Determine the relationship between the intensity of the transmitted light through analyzer and 'θ', the angle between the axes of polarizer and analyzer and to verify Malus Law. Write on the following points:

   (a) Apparatus used (2)

   (b) Schematic diagram (3)

   (c) Theory with working formula (3+1)

   (d) Procedure (6)

   (e) Give sample plots of θ versus intensity and also $cos^2\theta$ versus intensity. (3)

   (f) State what types of precautions should be taken. (2)

2. Determine the specific rotation (s) of a sugar solution using Polarimeter. Write on the following points:

   (a) Apparatus used (2)

   (b) Schematic diagram (3)

   (c) Theory with working formula (3+1)

   (d) Procedure (6)

   (e) Give a sample plot of c (concentration) versus θ (rotation produced by the sugar solution). Also mention clearly how one can measure s. (3)

   (f) State what types of precautions should be taken. (2)

3. Verify the Stefan's law of radiation. Write on the following points:

   (a) Apparatus used (2)

   (b) Circuit diagram (3)

(c) Principle (4)

(d) Procedure (6)

(e) Give a sample plot of *logR* (R, Filament Resistance) *logP* (P, Power radiated). Also mention clearly how one can verify the Stefan's law of radiation. (3)

(f) State what types of precautions should be taken. (2)