6. (a) Define retarded potentials. Derive the expressions for E and B fields (Jefimenko's equations) corresponding to retarded potentials. **10**

(b) What are retarded potentials ? Show that the retarded scalar potential satisfies the 4-D Poison's equation under Lorenz condition. **5**

7. (a) Obtain the Maxwell's equations in a hollow wave guide. Solve the wave equations using the BCs for TE mode in rectangular wave guide of dimensions 'a' and 'b' ($a > b$) and obtain the cut-off frequency, group velocity and phase velocity. **10**

(b) Discuss the DC and AC conductivity of plasma state. **5**

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Total Pages : 06

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May 2026

M. Sc. (Physics) (Second Semester)

Electrodynamics (PHP-108-V)

Time : 3 *Hours*] [*Maximum Marks* : 75

Note : It is compulsory to answer all the questions (1.5 marks each) of Part A in short. Answer any *four* questions from Part B in detail. Different sub-parts of a question are to be attempted adjacent to each other. Use of non-programmable simple calculator is allowed.

Part A

1. (a) State Poynting theorem. What is the significance of Poynting vector ? **1.5**

(b) The electric field associated with an e.m. wave in vacuum is given by $E = 20\cos(\omega t - 50x)\hat{y}$ V/m. Determine the angular frequency, ω associated with the wave. **1.5**

(c) Calculate the skin depth (δ) of copper with $\sigma = 5.8 \times 10^7$ S/m and $\mu = \mu_0 = 4\pi \times 10^{-7}$ H/m for an e.m. wave of frequency 1.6 MHz. **1.5**

(d) Consider the normal incidence of a plane electromagnetic wave on air-glass interface with $n^1 = 1$ and $n^2 = 1.5$. Determine the percentage transmittance. **1.5**

(e) Write the boundary conditions of electric and magnetic vectors for e.m. waves on interface of *two* different dielectric media. **1.5**

(f) Based on the scattering theory, explain, why sky appears blue and danger signals are of red colour. **1.5**

(g) Discuss the transformation of V and A so that the fields (E and B) remains invariant. **1.5**

(h) Define Lienard-Wiechert potentials. **1.5**

(i) Explain, how the plasma state is different from the gaseous state of matter. **1.5**

(j) A hollow rectangular waveguide has dimensions 6 cm and 4 cm. Determine its cut-off frequency for TE_{10} mode. **1.5**

Part B

2. (a) Discuss the method of images for a point charge + q placed at a distance d in front of a grounded conducting plane. Determine the magnitude of the total induced charge on the conductor. 7

(b) Two semi-infinite grounded conducting planes meet at right angle. In the region between them, a point charge + q is placed at a distance d from both the planes. Set up the image configuration and calculate the force on the point charge. 4

(c) Derive the equation of continuity. Discuss in detail how it led to modify the Ampere's circuital law. 4

3. (a) Derive the wave equation for propagation of e.m. waves in a conducting medium and discuss its solution considering monochromatic plane wave. Discuss the skin depth, refractive index and phase difference between the electric and magnetic vectors for a good conductor. 8

(b) The magnetic field associated with an e.m wave in vacuum is given by $B = 4 \times 10^{-5} \cos(kz - 6 \times 10^8 t)\ \hat{x}$ T. Determine the eletric field E, the wave vector K and the power per unit area carried with the wave. 7

4. (a) Discuss the reflection and refraction of a plane e. m. wave for normal incidence on the interface of two dielectric media. Obtain the Fresnel's relations and show that $R + T = 1$, where symbols have their usual meanings. Show that the state of polarization of electric vector remains unchanged under reflection and transmission of the wave at the interface of two linear dielectric media. 10

(b) Consider the interface between two linear dielectric media with permittivity ε_1 and ε_2 respectively. An electric field vector going form medium-1 to medium-2 makes angle θ_1 and θ_2 respectively with the normal. Show that $\frac{\tan\theta_1}{\tan\theta_2} = \frac{\varepsilon_1}{\varepsilon_2}$. 5

5. What is the phenomenon of dispersion? Differentiate between normal and anomalous dispersion. Discuss the dispersion of e.m. waves in gases and in solids and hence obtain the Clausius- Mossotti relation. 15