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

Please check whether you have got the right question paper.

N.B:
1. Attempt all six questions.
2. All questions carry equal marks.
3. Answer to the two sections in separate answer books.

Q.1
a) Define Poynting vector and obtain Poynting theorem giving the physical significance of each term in the final expression.
b) Obtain the dispersion relation
$K^2 = \frac{\mu \in w^2}{c^2}\left(1 + i4\frac{\pi\sigma}{w\in}\right)$
in a conducting medium.(Symbols have their usual meaning.)

OR

Q.2
a) What is polarizability? Derive the expression for the frequency dependence of atomic polarizability.
b) What are TE, TM and TEM modes of propagation in a wave guide?

Q.3 The Lienard-Wiechert electric field of a point charge is given by
$\bar{E} = e\left[\frac{(\bar{n}-\bar{\beta})(1-\beta^2)}{K^3R^2} + \frac{\bar{n}x\{(\bar{n}-\bar{\beta})x\bar{a}\}}{c^2K^3R}\right]$.
Obtain the expression for power radiated per unit solid angle for charged particle moving with collinear velocity and acceleration.

OR

Q.4 What are Lienard Wiechert potentials? Show that the retarded vector potential leads to the generalised Biot-Savart's law.

Q.5 a) Define four - dimensional gradient operator, four dimensional Laplacian operator, four current and four potential. Discuss, how it transforms under Lorentz transformations.
b) Obtain four dimensional analog of
i. Continuity equation
ii. Inhomogenous wave equation satisfied by $\emptyset$ and $\bar{A}$.

OR

Q.6 Define the field tensor $f_{\mu\nu}$ in terms of electromagnetic potentials and express it in terms of field components. Also, derive the covariant form of Maxwell's equations.

Section II

Q.7 a) Use Boltzman's entropy principle to define equilibrium between two systems in microcanonical ensemble.
b) Show that the Liouville equation has an equilibrium solution and define the partition function.

OR

Q.8 a) State the energy as a function of entropy for an ideal gas in microcanonial ensemble.
b) Derive the Helmholtz free energy for a gas of simple harmonic oscillators.

Q.9 a) Obtain the grand canonical ensemble partition function for a quantum ideal gas.
b) Calculate the total internal energy of a Bose gas in the normal phase for $T<Tc$ and $T>Tc$.

OR

Q.10 a) Use the grand canonical ensemble to obtain the equation of state of a Fermi gas.
b) For a system of N one-dimensional quantum mechanical harmonic oscillators, calculate the canonical partition function. Hence, find the energy and Helmholtz free energy of the system.

Q.11 Show that the LR (inductance-cum-resistance) circuit is an electrical analogue of Brown motion in kinetic theory. Obtain expressions for the relaxation time, the mean energy and the resistance of the LR circuit. Determine voltage and current fluctuations in the frequency range $[f, f+\Delta f]$.

OR

Q.12 Starting with the Langeuin force equation for Brownian motion, derive the fluctuation-dissipation theorem and discuss its significance.

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