Q.P. Code :10551

[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.

Section I

Q. 1 a) Consider Maxwell's equations in vacuum. Show that they admit plane wave solutions and hence show that the electromagnetic waves are transverse .

b) A plane wave is given by $\bar{B} = B_y \cos(wt - \emptyset)\widehat{e_y}$. Obtain the Poynting vector.

OR

Q. 2 a) Consider propagation of electromagnetic waves in a cylindrical wave guide. Show that the transverse components of electric and magnetic fields are completely determined by longitudinal components.

b) Write the boundary conditions for TE and TM waves.

Q. 3 The Lienard-Wiechert electric field for a point charge is given by

$$\bar{E} = e\left[\frac{(\bar{n} - \bar{\beta})(\bar{1} - \beta^2)}{K^3R^2} + \frac{\bar{n}\ x\ \{(\bar{n} - \bar{\beta})\ x\ \bar{a}\}}{C^2K^2R}\right]$$

Find the expression for the total power radiated by a non-relativistic charged particle.

OR

Q. 4 What are Lienard- Wiechert potentials? Obtain the L-W potentials for a point moving charge.

Q. 5 a) Define electromagnetic field strength tensor and express its components in terms of field components.

b) Show that the quantity $f_{\mu\nu}\, f^{\mu\nu}$ is equal to $2(\bar{B}^2 - \bar{E}^2)$.

OR

Q. 6 a) The Hamiltonian of a charged particle in external electromagnetic field is given by $H = \sqrt{(c\bar{p} - q\bar{A})^2 + m^2c^4} + q\emptyset$. Obtain from this the Lorentz force equation.

b) Show that the space part of the equation of motion $m\frac{dU\mu}{dE} = \frac{e}{c}\, f_{\mu\nu}\, U_\nu$ gives Lorentz force law.

Section II

Q. 7
a) For a system of N one-dimensional classical harmonic oscillators, calculate the canonical partition function. Hence find the energy and Helmholtz free energy of the system.
b) For the classical ideal gas in microcanonical ensemble, obtain the energy in terms of the entropy S, the volume V and the number of gas particles N.

OR

Q. 8
a) State and prove the Liouville theorem in phase space.
b) Consider an ideal gas of N particles having extreme relativistic energy $\in= pc$ and obeying classical statistics. Calculate the canonical partition function. Hence find the energy and the Helmholtz free energy of the system.

Q. 9
a) Calculate the entropy of the photon gas using grand canonical ensemble.
b) For a quantum system define microcanonical, canonical and grand canonical ensembles.
c) Show how the probability density can be used to obtain the ensemble average of a physical quantity.

OR

Q.10
a) State the condition for Bose-Einstein condensation temperature. Calculate the number of particles in the normal and condensed phases as a function of the temperature.
b) For the Fermi gas, evaluate PV|kT and $\overline{N}$ in the grand canonical ensemble. Hence obtain the the equation of state for PV|NkT.

Q.11
a) Integrate the Langevin equation for Brownian motion twice to obtain an expression for the mean square displacement $\langle x^2(t) \rangle$. Find the limiting behaviour of $\langle x^2(t) \rangle$ for t ≪ ĉ (relaxation time) and $t \to \infty$, and enterpret the results.
b) Define the Wiener Khintchine relations.

OR

Q.12
a) Show that the LR circuit is the electrical analogue of Brownian motion.
b) Obtain expressions for the relaxation time and the mean equilibrium energy of the LR circuit.
c) Express the resistance in terms of the correlation functions of the potential and current.
d) What are the potential and current fluctuations in the frequency range (f,f+Δf)?
