**MAY 2016** **P/ID 40005/PPHE**

Time : Three hours Maximum : 100 marks

PART A — (10 × 2 = 20 marks)

Answer ALL questions.

1. What are scattering amplitude and scattering cross-sections?

2. Define laboratory and center of mass coordinate system.

3. What do you mean by adiabatic perturbation?

4. What is termed as dipole approximation? Write the selection rules for dipole transistion?

5. Mention two inadequacies of Klein-Gordon equation.

6. Sketch the energy spectra of a relativistic Dirac free particle.

7. Write down any two properties of gamma matrices.

8. There are two observers in Lorentz frames $\Sigma$ and $\Sigma'$ . State whether the Dirac equation and its wave functions must be same for the two observers.

9. What are fields and field equations?

10. Define creation and annihilation operators.

PART B — (5 × 6 = 30 marks)

Answer ALL questions.

11. (a) Establish the connection between scattering cross-section and scattering amplitude.

Or

(b) Obtain the validity condition for Born approximation.

12. (a) Develop a perturbation theory for a sudden approximation.

Or

(b) State and prove any two properties of the density operator.

13. (a) Construct the plane wave solutions of the Klein-Gordon equation.

Or

(b) Establish that the Dirac theory requires a spin angular momentum of one half.

14. (a) Prove that Dirac equation can be rewritten as

$\left( S^{-1} \gamma_\mu S \frac{\partial}{\partial x_\mu} + \frac{mc}{\hbar} \right) S^{-1} \psi = 0$, where the various quantities have usual meaning.

Or

(b) Enumerate the salient features of Feynman's theory of positrons.

15. (a) Obtain the equation of motion of the Klein-Gordon field $\psi$ .

Or

(b) Write and explain the commutation relations for creation and annihilation operators of the electromagnetic field.

PART C — (5 × 10 = 50 marks)

Answer ALL questions.

16. (a) Determine the scattering amplitude for the screened Coulomb potential $V(r) = \frac{-Ze^2}{r} e^{-r/a}$ by Born's approximation. ($a$ is constant)

Or

(b) Express the scattering amplitude in terms of phase shifts.

17. (a) Obtain the expression for transition probability for a constant perturbation.

Or

(b) Develop a perturbation theory for slowly varying perturbations.

18. (a) Determine the energy spectrum and eigen-functions of Dirac's free particle.

Or

(b) Find the energy eigenvalues of a Dirac particle in a Coulomb potential.

19. (a) Obtain the complex conjugate of the Dirac equation

$$\left\{\gamma_\mu\left(p_\mu - \frac{eA_\mu}{c}\right) - imc\right\}\psi = 0$$ with standard notations.

Or

(b) Discuss the relativistic invariance of the Dirac equation.

20. (a) Determine the spectrum of the Klein-Gordon equation.

Or

(b) For the electromagnetic field, develop the occupation number representation corresponding to this field.

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