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OMDQ/D-20 **5241**

PHYSICS

Paper II

Advanced Quantum Mechanics

Time : Three Hours] [Maximum Marks : 60

Note : Attempt *Five* questions in all, selecting *one* question from each Unit. Q. No. **1** is compulsory.

1. (a) Find out the probability density and probability current density for Dirac equation. **3**

(b) Define Dirac Spinor. Using Dirac Spinor at rest, prove that the particle and anti-particle have opposite parity. **3**

(c) Differentiate Bosonic and Fermionic fields. Show that the commutation rule between creation and annihilation operators leads to symmetric wave function for bosonic field of identical particles. **3**

(d) What do you mean by contraction of an operator ? Show the same on a Feynman diagram. Give the importance of Wick's theorem. **3**

Unit I

2. (a) Obtain the expressions for the probability density and probability current density for K.G. equation. Why does K.G. equation fail to win recognition as a correct relativistic generalization of the Schrödinger equation ? **6**

(b) Show that the plane wave solution of K.G. equation admit both the positive and negative energy solutions. Write K.G. equation in covariant form also. **6**

3. (a) Differentiate K.G. and Dirac equation. Solve Dirac equation for free particle to obtain Dirac spinors. **9**

(b) What are the properties of α, β, γ-matrices ? Find out the commutation relation between matrices γ_1 and γ_2. **3**

Unit II

4. (a) Prove the covariance of relativisitic Dirac equation under Lorentz transformation. **9**

(b) Define Lamb shift. What is its physical significance ? **3**

5. (a) Within the framework of Dirac theory, work out to find the energy levels of Hydrogen atom in the relativisitc limits. **9**

(b) Show that Dirac matrices are even dimensional. **3**

Unit III

6. (a) Perform second quantization of a non-relativisitic field for Bosonic state. Also, generate the matrices for corresponding creation, annihilation and number operators for this field. **9**

(b) Justify with some examples that the quantum mechanical theory should be replaced by quantum field theory for a field with variable particles. **3**

7. (a) Distinguish between classical and quantum field. Work out to find the classical field equation in terms of Lagrangian. Also develop Hamiltonian equations for this field. **9**

(b) Evaluation the commutation between creation and annihilation operators for at unequal time for Bosonic field. **3**

Unit IV

8. (a) Perform step by step field quantization of electromagnetic field and evaluate the total energy of this field. **8**

(b) Write down the expression for classical field equation and corresponding Lagrangian density for Dirac field. Why is this field called Spinor field ? **4**

9. With the help of general expression for scattering matrix, assign scattering matix elements to various scattering processes represented by one and two vertices Feynman diagrams. Draw the corresponding Feynman diagrams. **12**