

Roll No. ....

Total Pages : 04

MDQ/D-20

5075

PHYSICS

PHY-301

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) What is Dirac Spinor ? For Dirac Spinor at rest, show that the particle and anti particle have opposite parity. **3**
- (b) What is Natural System of Units ? Show that the electric charge in these units is dimensionless. Find its magnitude as well. **3**
- (c) What is Feynman Propagator ? Show the same on a Feynman diagram. Also define Normal product. **3**
- (d) Define radiation field. Give the validity criterion for classical description of radiation field. **3**

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### Unit I

2. (a) Solve Dirac equation and find out Dirac spinors for a free particle. Give physical significance of negative energy states obtained. **8**
- (b) Show that the free particle with zero spin have both, positive and negative energy eigenvalues. What are the difficulties of K.G. theory ? **4**
3. (a) Test the correctness of Dirac equation by finding the spectrum of Hydrogen atom. **8**
- (b) Define  $\alpha$ ,  $\beta$  and  $\gamma$ -matrices in Dirac theory and mention their properties. **4**

### Unit II

4. (a) Work out to find second quantized Hamiltonian of a non-relativistic field for Fermions and generate the matrices for corresponding creation, annihilation and number operators. **8**
- (b) Distinguish between Bosonic and Fermionic Field. Show that the commutation rule between creation and annihilation operators leads to symmetric wave function for bosonic field of identical particles. **4**
5. (a) What do you understand by a classical field ? Derive the classical field equation in terms of both, Lagrangian density and Lagrangian. **8**

- (b) Evaluate the Poisson brackets :
- (i)  $[\psi(r, t), H]$
- (ii)  $[\psi(r, t), \pi(r', t)]$ . 4

### Unit III

6. (a) Evaluate the scattering matrix elements for various processes which can be represented on two vertices Feynman diagrams. 9
- (b) Differentiate Dyson and Wick's chronological products. Give the importance of Wick's theorem. 3
7. (a) What is Dirac Field ? Perform the field quantization of Dirac field and evaluate the total energy. 9
- (b) What is the need of Feynman diagrams ? Represent pair annihilation and pair creation on the Feynman diagrams using one and two vertices. 3

### Unit IV

8. (a) For a radiation field, represent creation and annihilation operators in terms of canonical variables and find the commutation relation between them. 8
- (b) Evaluate number-phase uncertainty for a quantized radiation field. 4

9. (a) What is Dipole Approximation ? Apply it to find transition probability for spontaneous emission of photon. **8**
- (b) Define gauge transformation. Give its significance. Prove that in case of radiation field, the Lorentz condition reduces to transversality condition. **4**