Name: **Enrolment No:**	

UPES

End Semester Examination, May 2025

Course: ADVANCED QUANTUM MECHANICS **Semester: II**

Program: M.Sc. Physics **Time : 03 hrs.**

Course Code: PHYS7032 **Max. Marks: 100**

Instructions:

- Attempt all questions in Section A, Section B and Section C.
- Support your answers with appropriate equations, diagrams, and derivations wherever necessary.
- Use standard scientific notation and units.

SECTION A

(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	State and explain the first-order correction to energy in non-degenerate time-independent perturbation theory.	**4**	**1**
Q 2	Write the basic principle of the variation method and explain its significance in quantum mechanics.	**4**	**2**
Q 3	Write the Dirac equation in covariant form and explain the physical significance of Dirac matrices.	**4**	**2**
Q 4	A beam of particles is scattered from a spherical potential well. Calculate the total scattering cross-section using the partial wave approximation.	**4**	**3**
Q 5	Calculate the total energy of a particle with the rest mass m = 0.511 MeV/c2 and momentum p = 1 MeV/c.	**4**	**3**
	SECTION B **(4Qx10M= 40 Marks)**		
Q 6	Derive the expression for the first-order correction to the wave function in non-degenerate perturbation theory.	**10**	**1**
Q 7	Consider two non-interacting identical particles in a one-dimensional infinite potential well of width L. If both are in the lowest two energy levels, write down the total wavefunctions for: a. Bosons b. Fermions	**10**	**2**
Q 8	Apply the variation method to estimate the ground state energy of the helium atom.	**10**	**3**
Q 9	Explain the symmetric and antisymmetric wavefunction and drive the Slater Determinant for N-particle system. Show that two fermions cannot occupy the same quantum state using the antisymmetric wavefunction. **OR**	**10**	**3**

	Using the Dirac matrices, show how the Dirac equation reduces to the Pauli equation in the non-relativistic limit.		
SECTION-C (2Qx20M=40 Marks)			
Q 10	a. Apply the concept of partial wave analysis in scattering theory. b. Derive an expression for the scattering amplitude and discuss its application to low energy scattering.	**10+10**	**3**
Q 11	Starting from the Klein-Gordon equation, derive its solution for a free particle and discuss the difficulties in physical interpretation. Compare it with the Dirac equation. **OR** Derive the semi-classical expression for the transition rate of emission or absorption of radiation by an atom interacting with an electromagnetic field.	**20**	**3**