PG Even Semester Examination, May 2025

PHYSICS

(2nd Semester)

Course No.: PHYCC-552

(Advanced Quantum Mechanics)

Full Marks: 70

Pass Marks: 28

Time: 3 hours

The figures in the right margin indicate full marks for the question.
Answer any five questions selecting one from each unit.

UNIT-I

1. (a) Find the connection formula at the linear turning point in case of WKB approximation. 8

   (b) Explain adiabatic approximation with an example. 6

2. (a) A system at initial state ψ_i is perturbed by an external potential V for a duration of time t. Find out the probability of finding the system at a final state ψ_f, after the perturbation is withdrawn. One may assume, during the time the perturbation was acting, V was constant. 10

   (b) Find the probability density per unit time, if the state ψ_f is composed of several closely spaced state. 4

Turn Over

UNIT-II

3. (a) Obtain the relation between the differential cross sections in laboratory frame with that of centre of mass frame. 5

   (b) Calculate the scattering cross section in centre of mass frame in case of a 3D hard sphere. 9

4. Studying low energy scattering from the potential 8+3+3=14

$$V= \begin{cases} V_0, & r>a \\ 0, & r<a \end{cases}$$

discuss the S-wave resonance and the Ramsauer Effect.

UNIT-III

5. (a) Find the Lippman-Schwinger Solution for the Schrodinger Equation near a scattering centre. 8

   (b) What is Born Approximation? Discuss its validity. 6

6. Show that the first Born approximation is not suitable for studying the scattering of incoming charged particle having Coulomb interaction with scattering centre. Find out the differential scattering Cross Section for such an interaction treating Coulomb potential as a limiting case for Yukawa Potential. 4+10=14

UNIT-IV

7. (a) Convert the non-relativistic Schrodinger Equation into a relativistic one by using the mass-energy relation $E^2=p^2c^2+m^2c^4$.

   (b) Hence obtain the conservation of probability current density equation and compare with the corresponding non-relativistic one. Suggest meaningful modifications, if necessary.

   (c) Also obtain a plane wave solution for the relativisitic Schrodinger equation. 5+5+4=14

8. (a) Write down the Dirac Hamiltonian and discuss the properties of Dirac matrices. 6

   (b) Obtain plane wave solutions of the Dirac equation. 8

UNIT-V

9. (a) State and prove Noether's theorem in scalar field theory. 8

   (b) Show that invariance of action integral under space-time translation leads to conservation of energy-momentum. 6

10. Write notes on : 7+7+14

    (a) Normal Ordering of Operators.

    (b) Second Quantization

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