PG Even Semester Examination, May 2025

PHYSICS

(2nd Semester)

Course No.: PHY-202

(Quantum Mechanics-II)

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) In a nondegenerate time independent perturbation theory, the unperturbed Hamiltonain H_0 is a two level Hamiltonian, having energy eigenvalues and eigenstates as $E_1^{(0)}$ and $E_2^{(0)}$ with eigenstates $|1^{(0)}\rangle$ and $|2^{(0)}\rangle$. A weak time independent potential V is acted on the system. Find the eigenvalues and eigenstates of the total Hamailtonian $H= H_0+V$. 8

   (b) In the previous example, consider one energy level is twofold degenerate, i.e., have two different eigenstates $|1^{(0)}\rangle$ and $|1'^{(O)}\rangle$ corresponding to same energy $E_1^{(0)}$. A weak time- independent potential V is acted on the system. Find the eigenvalues and eigenstates of the total Hamiltonian $H= H_0+V$. 6

2. Calculate the time dependent dipole moment induced in a one dimensional harmonic oscillator by an electric field $E_0 \cos \omega t$ turned on at t=0 14

UNIT-II

3. (a) Find the criterion of validity of WKB approximation. 4

   (b) Find the connection formula at the linear turning point in WKB approximation. 6

   (c) Using Bohr-Sommerfeld quantization rule, show that WKB approximation gives the correct energy eigenvalues for harmonic oscillator. 4

4. Using variational approximation method, estimate the ground state energy of Helium atom. 14

UNIT-III

5. Using partial wave analysis, find the differential scattering cross section in terms of phase shifts. Discuss the result in low energy limit. 10+4=14

6. (a) Obtain the relation between the differential cross sections in centre of mass frame with that of laboratory frame. 6

   (b) Explain the validity of Born's first order approximation. 4

   (c) State and prove optical theorem. 4

UNIT-IV

7. (a) Prove that the relativistic generalisation of the Schrodinger equation gives rise the Klein-Gordon equation. 3

   (b) Obtain the equation of continuity from Klein-Gordan equation. 3

   (c) Explain why Klein-Gordon equation is not a good candidate for a single particle relativistic wave equation. 3

   (d) Show that angular momentum operator commutes with the K-G Hamiltonian. 5

8. (a) Obtain the properties of gamma matrices used in Dirac equation. 6

   (b) Show the covariance of Dirac equation. 8

UNIT-V

9. Quantise the scalar field and find the commutation relation between the field and canonically conjugate operator. 14

10. State and prove Nother's theorem. Using the theorem, show that translation symmetry leads to conservation of energy-mommentum for scalar field. 8+6=14

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