PG (NEP) EVEN SEMESTER EXAMINATION, 2023

PHYSICS

2nd Semester

Course No. : PHY - 552

(Advanced Quantum Mechanics)

Full Marks : 70

Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

(Answer five questions, taking one from each unit)

UNIT - I

1. Explain the WKB approximation method and obtain the transmission and reflection probabilities for a particle crossing potential well. 5 + 9 = 14

2. (a) Obtain Fermi's golden rule as the total transition probability per unit time under a time-dependent perturbing Hamiltonian. 8

   (b) Obtain the transition probability for a perturbation on a system that is harmonically dependent on time. 6

UNIT - II

3. (a) Define differential cross section of scattering and establish a relation between the impact parameter and differential cross section. 8

   (b) Determine the differential cross section for Rutherford scattering. 6

4. Using partial wave analysis, show that the total scattering cross section (σ_T) is given by

$$\sigma_T = \frac{4\pi}{k^2}\sum_{l=0}^{\infty}(2l+1)\sin^2\delta_l$$

where the symbols have their usual meanings. 14

UNIT - III

5. (a) Discuss Born approximation and its validity. 8

   (b) Deduce the total cross section of scattering from a square well potential in Born approximation. 6

6. Using Green's function technique, solve the Schrodinger equation for scattering problem. Hence obtain the scattering amplitude in the first Born approximation. 14

UNIT - IV

7. (a) Obtain the Klein-Gordon equation as a relativistic wave equation and discuss its shortcomings. 6

   (b) Obtain the Dirac equation as a satisfactory relativistic wave equation. Discuss the properties of the Dirac matrices. 8

8. Derive the energy spectrum of a plane wave using Dirac theory. 14

UNIT - V

9. State and prove Noether's theorem. Using the theorem, show that translational symmetry leads to the conservation of energy-momentum for scalar field. 2 + 7 + 5 = 14

10. Using the canonical commutation relations between the field operator of a real scalar field and its conjugate momentum operator derive the commutation relations between the creation and annihilation operators. Hence quantize the real scalar field. 14

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