PG (CBCS) EVEN SEMESTER EXAMINATION, 2023

PHYSICS

2nd Semester

Course No. : PHYCC - 202

(Quantum Mechanics - II)

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. (a) A system with a non-degenerate Hamiltonian (H_0) is perturbed by a time independent Hamiltonian (H'). Find the expression of the wavefunction and the energy of the system up to second order approximate. 10

   (b) A linear harmonic oscillator is perturbed by $H' = cx$, where c is a constant. Estimate the energy of the n^{th} oscillator level up to second order perturbation. 4

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

4. (a) Explain briefly the variational method and its uses. 5

(b) Estimate the ground state energy of helium using variational method. 9

UNIT - III

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

6. 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 - 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 plane wave solution for Dirac equation. 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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