D3APH2301 **(2 Pages)** **Name.....**
Reg.No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, NOVEMBER 2024
(Regular/Improvement/Supplementary)

PHYSICS
FPHY3C09 - QUANTUM MECHANICS-II

Time: 3 Hours **Maximum Weightage: 30**

Part A: Short answer questions. Answer *all* questions. Each carries *one* weightage.

1. Give the general formulation of time-independent perturbation theory.
2. Write a short note on the weak field and strong field Zeeman effect.
3. Discuss briefly the validity condition of WKB approximation.
4. Explain the principle of variational method.
5. Construct the Hamiltonian for an electron in an electromagnetic field. What is the criterion for dipole approximation?
6. What are negative energy states? Explain the concept of 'hole'.
7. Explain how the Klein-Gordon equation leads to positive and negative values of probability density.
8. Obtain the Dirac equation in covariant form.

(8 × 1 = 8 weightage)

Part B: Essay questions. Answer any *two* questions. Each carries *five* weightage.

9. Using the degenerate time-independent perturbation theory discuss the fine structure correction to the energy levels of Hydrogen atom.
10. Discuss the method of partial waves with respect to scattering by a central potential. Find the total scattering cross section.
11. Obtain the Dirac Hamiltonian for a free particle. Explain the properties of Dirac matrices. Evaluate the spin of Dirac Particle.
12. Discuss time-dependent perturbation theory. What is the transition probability when a system is subjected to a harmonic perturbation?

(2 × 5 = 10 weightage)

Part C: Problems. Answer any *four* questions. Each carries *three* weightage.

13. Evaluate the first-order correction to the energy of the n^{th} state of the anharmonic oscillator having the potential $V = \frac{1}{2}m\omega^2x^2 + cx^4$ ($cx^4 \ll \frac{1}{2}m\omega^2x^2$).

(P.T.O.)

14. Using variational principle find the ground state energy of one-dimensional harmonic oscillator.
15. Find transmission coefficient of a potential barrier using WKB method.
16. Derive Fermi Golden Rule.
17. Discuss the Stark effect of n=2 level in Hydrogen atom using degenerate perturbation theory.
18. Derive the equation of continuity using Dirac equation and hence prove that the probability density in Dirac theory is positive definite.
19. What is scattering length? How is it related to zero energy scattering cross section?

(4 × 3 = 12 weightage)