D3APH2401 (2 Pages) Name............................
Reg.No.........................

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, NOVEMBER 2025
(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 one example of a physical system where perturbation theory is applied.
2. Define density of states. Why is it important in transition to a continuum?
3. State the WKB quantization condition.
4. Write the transition probability for a system under sinusoidal perturbation.
5. Give the features of Klein Gordan equation.
6. What are Dirac spinors?
7. Outline the method to remove degeneracy using perturbation theory.
8. Discuss quadratic Stark effect.

(8 × 1 = 8 weightage)

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

9. Obtain the first order and second order correction in the energy of the nondegenerate state of a system using time-independent perturbation theory.
10. Discuss how the time dependent perturbation theory is applied to find the scattering cross section in the first order Born approximation.
11. Estimate the ground state energy of the helium atom using variational method.
12. Explain the method of partial waves in scattering theory. Derive the expression for the scattering amplitude in terms of phase shifts.

(2 × 5 = 10 weightage)

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

13. Show that the orbital angular momentum **L** is not conserved for a Dirac particle in a central potential. Show that the conserved quantity is the total angular momentum **J= L+S**.

(P.T.O.)

14. Apply the WKB method to a potential well with two vertical walls.
15. Show that the Dirac's particles have spin ½.
16. Obtain the first order correction in the energy of a linear harmonic oscillator under a perturbation $V' = bx^2$ where b is a constant and x is the displacement from the mean position. Compare with the exact result.
17. The forward scattering amplitude for a process is measured as:

    $f(0) = (2.50 + 1.20\, i) \times 10^{-15}$ m.

    If the incident wave number is $k = 2.00 \times 10^{10}\ m^{-1}$, compute the total cross section σ_{tot} using the optical theorem.
18. Calculate the energy of the n^{th} excited state to first-order perturbation for a one-dimensional box potential of length 2L, with walls at x= -L and x= L, which is modified at the bottom by the following perturbations with

    $V_0 << 1$. $V'(x) = \begin{cases} -V_0 & ;\ 0 \le x \le L \\ 0 & ;\ elsewhere \end{cases}$
19. Show that Dirac matrices α_x, α_y, α_z and β are unimodular and they anti- commute with each other by choosing a pair.

v0063 (4 × 3 = 12 weightage)