A–0430

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MSCPH-503

Master of Science Physics (MSCPH)

Quantum Mechanics

Examination, June 2025

Time : 2:00 Hrs. Max. Marks : 70

Note* :–** This paper is of Seventy (70) marks divided into Two (02) Sections 'A' and 'B'. Attempt the questions contained in these Sections according to the detailed instructions given therein. ***Candidates should limit their answers to the questions on the given answer sheet. No additional (B) answer sheet will be issued.

Section–A

Long Answer Type Questions 2×19=38

***Note* :–** Section 'A' contains Five (05) Long-answer type questions of Nineteen (19) marks each. Learners are required to answer any *two* (02) questions only.

1. Discuss the basic results which led to the formulation of the wave concept of matter. What are de-Broglie waves ? Discuss their wavelength and explain how they afford a correct description of the motion of a particle.

2. Obtain the schrodinger equation for rectangular barrier penetration problem to obtain eigen values and eigen functions.

3. Explain in detail the scattering by identical particles quantum mechanically. Compare it with the classical expression. Is there any difference between the two ? If yes, then what is the reason ?

4. (a) What do you mean by an operator ? Write operators associated with energy and momentum.

   (b) Show that momentum operator $\frac{\hbar}{i}\frac{\partial}{\partial x}$ is Hermitian.

5. Consider two dimensional harmonic oscillator with the unperturbed Hamiltonian

$$H^{(0)} = \frac{p_x^2}{2m} + \frac{p_y^2}{2m} + \frac{1}{2}m\omega^2(x^2 + y^2)$$

Which has a level with energy $E = 2\hbar\omega$ and is two fold degenerate. The oscillator is subjected to a perturbation $\lambda H = \lambda m\omega^2 xy$, $\lambda << 1$. Show by using first order perturbation theory that the level may split into a doublet. Also find the zeroth order eigen function associated with each member of the doublet.

Section–B

Short Answer Type Questions 4×8=32

***Note* :–** Section 'B' contains Eight (08) Short-answer type questions of Eight (08) marks each. Learners are required to answer any *four* (04) questions only.

1. Explain in brief the orthogonal and normalized wave function. If $\Psi = A \sin (K_x x + B)$ is normalized in the range $0 \leq x \leq a$, then evaluate constant A.

2. Write down the postulates of Bohr's model. Discuss the different spectral series obtained in the emission spectrum of hydrogen atom and in this reference, explain Ritz combination principle.

3. Discuss Born approximation in scattering theory and apply it to obtain Rutherford formula.

4. State the principles of matrix mechanics and apply them to the case of linear operators.

5. Solve Schrodinger's equation for a particle in 1-D box of length L and obtain its Eigen values and Eigen functions. Draw a graph of its first three Eigen functions.

6. Determine $\Psi\Psi^*$ when Ψ equals :

   (a) Ne^{-ikt}

   (b) $e^{ix} - e^{-ix}$

7. If L_x L_y and L_z are orbital angular momentum operator, show that :

$$[L_x, L_y] = i\hbar L_z$$

8. Write short notes on any *three* :

   (a) Dirac matrices

   (b) Negative energy state of an electron

   (c) Coupling of angular momenta

   (d) Clebsch-Gordan coefficients

   (e) Pauli spin operators

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