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MPHY-504

Quantum Mechanics

M.Sc. Physics (MSCPHY-20)

Ist Semester, Examination, June 2022

Time : 2 Hours Max. Marks : 40

Note : This paper is of Forty (40) marks divided into two (02) Sections A and B. Attempt the questions contained in these sections according to the detailed instructions given therein.

SECTION – A

(Long-answer – type questions)

Note : Section 'A' contains Five (05) long-answer-type questions of Ten (10) marks each. Learners are required to answer any Two (02) questions only.

(2×10=20)

1. What is angular momentum? Suppose that L^2 is measured for a free particle and the value $6\hbar^2$ is found. If L_y is then measured, what possible values can result?

P.T.O.

2. Consider a one dimensional potential well in the form of a delta function V(x) = - A (x). Show that there is only one bound state of the particle. Find energy eigen value and eigen state.
3. Derive Schrödinger's time dependent wave equation and prove that

$$\frac{d\rho}{dt} + \nabla . S = 0$$

Where ρ = probability density

S = probability current.

4. Discuss the addition of two angular momenta and obtain the relation between the eigen functions in the couped and uncoupled representations. What are Clebsch-Gordan coefficients?
5. Explain 'variation method' and use it to evaluate ground state energy of hydrogen atom.

SECTION – B

(Short – answer – type questions)

Note: Section 'B' contains Eight (08) short – answer type questions of Five (5) marks each. Learners are required to answer any Four (04) questions only. (4×5 = 20)

P.T.O.

1. Show that operators L_Z, L and L^2 are Hermitian operators.

2. Show that:

(a) $\left[L_x^2, L_y^2\right] = \left[L_y^2, L_z^2\right] = \left[L_z^2, L_x^2\right] = 0$

(b) $\left[L_x, r^2\right] = \left[L_y, r^2\right] = \left[L_z, r^2\right] = 0$

Where the symbols having their usual meaning.

3. For a wave function of a particle $\varphi(x) = \sqrt{2}$ /L sin (π x/L). Find the probability of finding the particle in the region – L/2 <x<L/2.

4. Describe WKB method for the solution of Schrödinger wave equation in a potential field and discuss its validity.

5. A linear harmonic oscillator is perturbed

V'(x) = K x^4. Find the first order correction to energy E_n (0).

P.T.O.

6. State and prove Ehrenfest's theorem. Interpret the results in terms of the correspondence principle.

7. Give a simple derivation of Klein – Gordon equation. Discuss the difficulties historically associated with the interpretation of this equation and how they have been overcome.

8. Derive the Dirac equation for an electron in electrostatic field and show that spin of the electron follows as a consequence of equation.
