Quantum Mechanics 2022

SC1.203

Quiz-III

11/11/2022 || Time 60 Mins

1) Suppose a delta-function bump appears in the centre of an infinite square well:

$$V(x) = \begin{cases} \alpha(x - a/2) & \text{if } 0 \leq x \leq a \\ \infty & \text{otherwise} \end{cases}$$

where α is a constant. Find the first-order corrections to the allowed energies and explain why the energies are not perturbed for even n.

2) Three particles are in three distinct one-particle states $\psi_a(x)$, $\psi_b(x)$, and $\psi_c(x)$. Consider various possibilities and list the different three-particle states can you construct.

3) Place a hydrogen nucleus (proton) at the origin, calculate $\langle x \rangle$, $\langle x^2 \rangle$ in terms of the Bohr radius for the electron. What is the most probable value of r? Assume the electron to be in the ground state.

4) Find the spectrum and the eigenfunctions of the operator $\hat{Q} = i\frac{d}{d\phi}$ where ϕ is the usual polar coordinate. Is it hermitian?

5) Consider a three-dimensional harmonic oscillator $V(\mathbf{r}) = \frac{1}{2}m\omega^2 r^2$. What is the energy of the n^{th} state? What is the degeneracy of E_n?