

# 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  $\alpha$  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  $\phi$  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  $n^{\text{th}}$  state? What is the degeneracy of  $E_n$ ?