## Question and Answers

### 1) What is wavefunction?

**Answer:** A wave function is a complex-valued mathematical function, typically denoted by the Greek letter ψ (psi), that completely describes the quantum state of an isolated system.

### 2) Why the concept of wavefunction emerges in quantum mechanics?

**Answer:** The wave function emerges because it:

- bridges particle-like detections and underlying wave behavior
- encodes probabilities essential for inherently uncertain observables
- supports superposition and interference through complex phase relationships

**Explanation:** Classical mechanics treats particles as point-like objects following definite trajectories, but experiments at the atomic scale revealed behaviour that simply could not be captured by that picture alone. The double-slit experiment shows single electrons producing interference fringes, and the photoelectric effect confirmed light behave as discrete quanta. These wave-particle dualities demanded a new formalism beyond deterministic paths and forces.

Louis de Broglie proposed that particles carry a wavelength ($\lambda = h/p$), unifying matter and wave phenomena. Very soon this hypothesis was experimentally demonstrated by electron diffraction experiments.

Now, one may ask the following: If electrons are waves, then what equation governs their evolution?

By analogy with classical wave equations, Schrödinger derived time-dependent wave equation, introducing a function $\psi(x, t)$ whose dynamics *encode* all allowed behaviors of a quantum system. But, unlike amplitude of a water wave, $\psi(\mathrm{x}, \mathrm{t})$ does not represent a physical shaking.

Max Born realized that $|\psi(\mathrm{x}, \mathrm{t})|^2$ gives the probability density for finding a particle at (x). This statistical turn explains why quantum mechanics cannot predict single outcomes but only their distributions. Thus, resolving the apparent randomness in measurements.

The complex values in $\psi(x, t)$ carry both magnitude and phase, enabling rich interference effects. The superposition principle follows: any linear combination of valid $\psi(x, t)$ functions is also a solution, mirroring the overlap of wave-like possibilities. Complex phases determine constructive or destructive interference, which is central to phenomena from tunneling to quantum computing.