NAXXATRA
A CONSTELLATION OF CURIOUS MINDS

Quantum Mechanics for Beginners

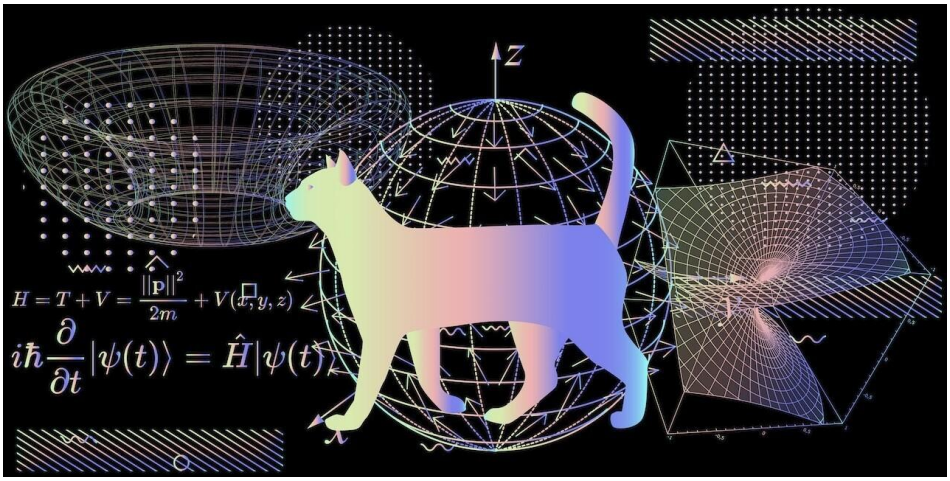
30 Days Crash Course (Intermediate Level)

Summary

1. Description: *Quantum mechanics is a fascinating yet enigmatic topic of study that has captivated the minds of physicists for decades. There are so many weird possibilities a quantum system can do that seem alien to the macroscopic world. Like how can a particle cross a barrier greater than its total energy? What does it mean that we can't measure the position and momentum of a particle simultaneously? In this course, we will not only try to understand the quantum world but also put these ideas into mathematical equations.*

2. Topics: *Mathematical Tools for Quantum Mechanics and its Postulates, The Formalisms - Schrodinger, Heisenberg, and Path Integral, Quantum Harmonic Oscillator, Quantum Tunneling, Hydrogen Atom, Spin Kinematics, Symmetries, Time Independent and dependent perturbations, Scattering Problems, Introduction to Relativistic Quantum Mechanics.*

3. Grade/Level: Intermediate (Ideal for Undergraduate students to senior undergraduates and above). The Crash course will be rigorous.

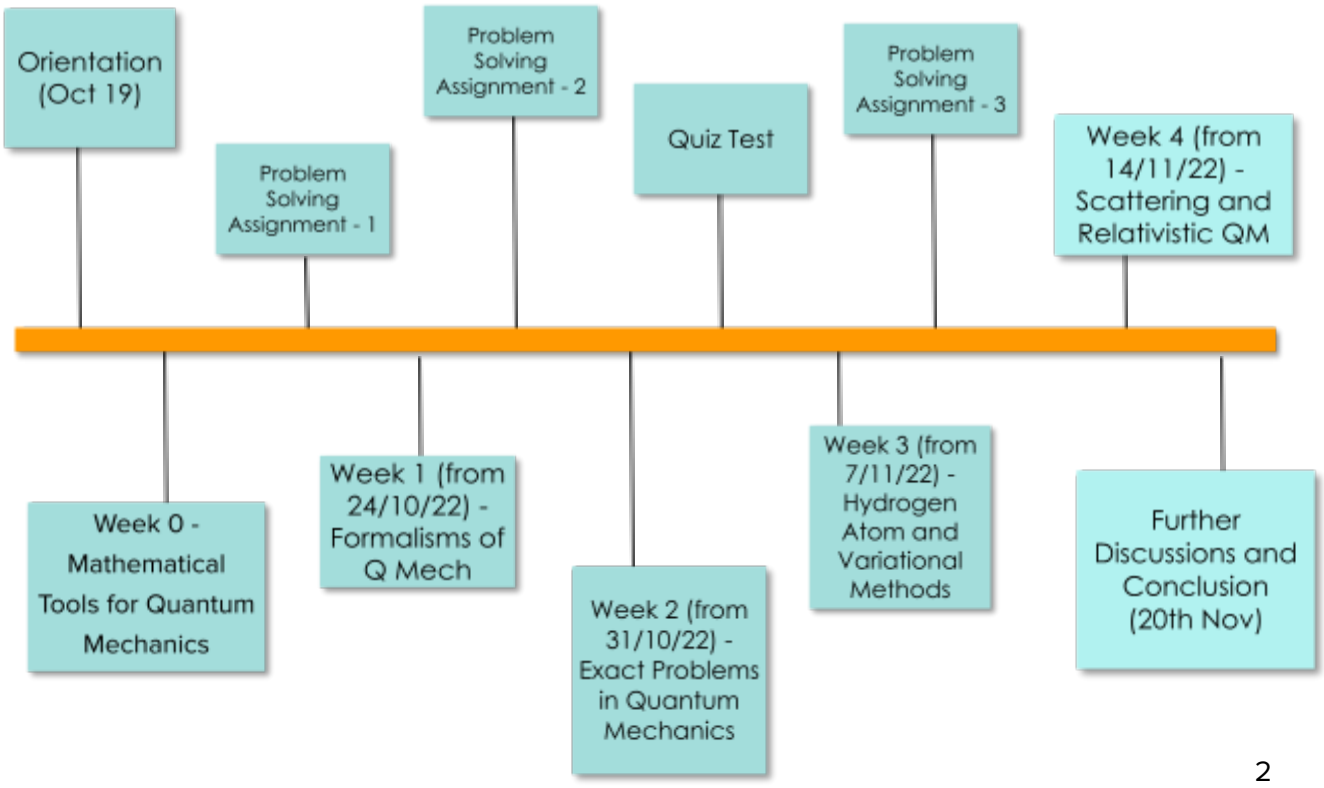


Overview

Learning Outcomes

a. Understand the quantum rules that seem entirely alien to macroscopic beings like us, where the behavior of particles become less deterministic and more probabilistic as their size and mass reduce.
b. Quantizing the simple harmonic oscillator. Know how a particle can cross a barrier greater than its total energy - Quantum Tunneling.
c. Model one-electron system in Coulomb Potential (Hydrogen atom), Multi-electron atoms, and Spin Kinematics. Solving the Scattering Problems.
d. Understand the symmetries in Quantum Mechanics and What happens when a system is Perturbed.
e. Lorentz invariance and Schrodinger equation. Understand the basics of Relativistic Quantum Mechanics - Governing equation for relativistic particles - The Dirac Equation.

TIMELINE OF THE PROJECT



Tentative timings and Days of Lectures: Classes will be held from **6:00 PM to 7:30 PM** on Mondays, Tuesdays, Thursdays, Fridays, and Saturdays. Informal Discussions if needed will be held on the remaining days.

Prerequisites: Basics of Matrices, differentiation, integration, differential equations, linear algebra, Classical mechanics upto Newtonian formulation.

WEEKLY BREAKDOWN

Week 0 - Mathematical Tools for Quantum Mechanics

- Linear Vector Spaces, Hilbert Space, Dual Space.
- Linear Transformation and Linear Operators.
- Eigenvalue problem. Unitary Transformations.
- Quantum Mechanics in Infinite Dimensions - Position and Momentum Representation.

Week 1 - The Formalisms

- Evolution of system by Unitary Matrix - Heisenberg formalism
- Wave mechanics - Schrodinger formalism
- Path Integral Formalism

Week 2 - Exact Problems

- Classical and Quantum Harmonic Oscillator.
- A particle in a 1D, 2D, and 3D potential well and degeneracies.
- Single-Step Potential (Scattering Problem), Scattering Matrix
- Symmetries - N particles in 1-D, Identical Particles. Invariance - Translation, Time, Parity.
- Rotational Invariance and Eigenvalue Problem of L^2 and L_z

Week 3 - Hydrogen Atom and Variational Methods

- The Hydrogen Atom
- Spin and Addition of Angular Momenta
- Variational Methods

Week 4 - Scattering and Relativistic Quantum Mechanics

- 1-D Scattering, Born Approximations, Partial Wave Expansion
- Klein Gordon Equation and Dirac Equation.
- Imaginary Time, Fermion Path Integrals.