Introduction to Quantum Mechanics
MSc Course

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University Name

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Welcome and Course Introduction

Welcome!

Welcome to the MSc Quantum Mechanics course! We will explore the foundational and advanced aspects of quantum theory, essential for modern physics and research.

This course is designed to challenge and expand your understanding through theory, math, and practical applications.

Teacher Incharge

- Professor: Prince A Ganai
- Research Areas: Blackhole Thermodynamics, Quatum Gravity, Quantum Information, and Large scale structure of Universe
- Contact: princeganai@nitsri.ac.in
- Office Hours: 8 AM – 5 PM Mon-Friday

Course Goals and Objectives

We aim to:

- Master fundamental principles and postulates of quantum mechanics
- Build strong mathematical skills for quantum theory
- Understand key quantum systems and their behavior
- Prepare for research and advanced studies
- Encourage critical thinking and scientific inquiry

Course Syllabus Overview

1. Introduction & Historical Background
2. Mathematical Foundations
3. Quantum Formalism and Postulates
4. One-Dimensional Problems
5. Angular Momentum and Spin
6. Quantum Dynamics
7. Approximation Techniques
8. Identical Particles and Statistics
9. Three-Dimensional Quantum Systems
10. Measurement and Interpretation
11. Advanced Topics and Applications

Weekly Course Breakdown (Weeks 1–5)

- Week 1: Introduction, History, Course Overview
- Week 2: Mathematical Tools and Hilbert Spaces
- Week 3: Operators, Commutators, and Uncertainty
- Week 4: Schrödinger Equation and Postulates
- Week 5: Particle in a Box and Quantum Wells

Homework and assignments will reinforce each topic.

Weekly Course Breakdown (Weeks 6–10)

- Week 6: Quantum Tunneling & Harmonic Oscillator
- Week 7: Angular Momentum I — Orbital
- Week 8: Angular Momentum II — Spin Addition
- Week 9: Quantum Dynamics and Time Evolution
- Week 10: Perturbation and Variational Methods

Weekly Course Breakdown (Weeks 11–15)

- Week 11: WKB and Time-Dependent Perturbation
- Week 12: Identical Particles and Quantum Statistics
- Week 13: Hydrogen Atom and Central Force
- Week 14: Measurement, Density Matrices, Entanglement
- Week 15: Applications, Advanced Topics, and Review

Assessment and Grading

- Homework Assignments 10%
- Midterm Exam 26%
- Final Exam 50%
- Participation and Presentations 14%

Late submissions accepted only with valid reasons. Seek help early!

Recommended Textbooks and Resources

- Griffiths, *Introduction to Quantum Mechanics*
- Shankar, *Principles of Quantum Mechanics*
- Sakurai, *Modern Quantum Mechanics*
- Cohen-Tannoudji, *Quantum Mechanics*

Lecture notes and supplementary papers will be shared regularly.

Tips for Success

- Review lecture notes regularly
- Practice problem solving actively
- Form study groups for discussion
- Ask questions: in class, office hours, or online
- Read ahead on topics for better engagement

What Is Quantum Mechanics?

Question 1: What comes to mind when you hear "Quantum Mechanics"?

Write down your thoughts or discuss with a partner for 2 minutes.

Share Your Ideas

Let's hear some ideas from you!

- What makes quantum mechanics fundamentally different from classical physics?
- Can you name any quantum phenomena or effects you know?
- What questions do you hope this course will answer?

Question 2: What does it mean for particles to behave like waves?

Examples you may know: Electron diffraction, light interference

Key Highlights

- Quantum objects behave with dual nature particle and wave
- Classical physics breaks down at microscopic scales
- Quantum theory explains phenomena classical mechanics cannot
- Measurement affects quantum systems profoundly

Historical Milestones in Quantum Mechanics

- Max Planck's black-body radiation (1900)
- Einstein's photoelectric effect explanation (1905)
- Bohr's model of the hydrogen atom (1913)
- De Broglie's matter waves (1924)
- Schrödinger's wave equation (1926)

Physics Problems Addressed by Quantum Mechanics

- Black-body radiation paradox
- Stability of atoms
- Photoelectric effect puzzle
- Atomic emission spectra
- Electron diffraction experiments

Preview: Fundamental Postulates of QM

- State of a system described by a vector in Hilbert space
- Observables represented by linear Hermitian operators
- Measurement results correspond to eigenvalues of these operators
- Time evolution governed by the Schrödinger equation

We'll explore these rigorously soon!

Key Concepts to Master

- Wavefunctions and probabilistic interpretation
- Operators and eigenproblems
- Uncertainty principle and commutation relations
- Quantum tunneling and barriers
- Angular momentum and spin

Quick Quiz!

True or False?

- Classical physics can explain black-body radiation. **(False)**
- Particles can exhibit wave-like properties. **(True)**
- The Schrödinger equation is central to quantum dynamics. **(True)**
- Quantum states are vectors in Euclidean space. **(False; Hilbert space instead)**

Class Participation and Collaboration

- Active discussion during lectures encouraged
- Group problem-solving sessions planned
- Share insights or doubts via forums or office hours

Homework Assignment #1

- Read Griffiths Chapter 1 (Introduction)
- Write a one-page reflection:
  "What do you find most intriguing or puzzling about quantum mechanics?"
- Prepare two questions for next lecture's discussion

Mathematical Foundations of Quantum Mechanics

Topics:

- Vector spaces and inner products
- State vectors and bras/kets
- Operators and eigenvalue problems

Questions and Open Discussion

Please ask any questions or share your thoughts.

Let's make this a fruitful and engaging course together!

Thank You!

Looking forward to a great semester with you all.