PHYS30201 Physics with Theoretical Physics Core Unit
Prof. M. C. Birse Physics Option Unit (in place of PHYS30101)
Credit Rating: 10

Mathematical Fundamentals of Quantum Mechanics (M)

Prerequisites PHYS20101; PHYS20672 or MATH10212

PHYS20252 is recommended but not essential.

Follow-up units PHYS40202 and fourth year courses

Classes 22 lectures in S5

Assessment 1 hour 30 minutes examination in January

Recommended texts

Shankar, R. *Principles of Quantum Mechanics* 2nd ed. (Plenum 1994)

Gasiorowicz, S. *Quantum Physics*, 3rd ed. (Wiley, 2003)

Mandl, F. *Quantum Mechanics* (Wiley, 1992)

Griffths, D. J. *Introduction to Quantum Mechanics*, 2nd ed (CUP, 2017)

Feedback

Feedback will be available on students' solutions to examples sheets through examples classes, and model answers will be issued.

Aims

To develop an understanding of quantum mechanics, in particular the mathematical structures underpinning it.

Learning outcomes

On completion of the course, successful students should be able to:

1. Use Dirac notation to represent quantum-mechanical states and manipulate operators in terms of their matrix elements
2. Solve a variety of problems with model and more realistic Hamiltonians, demonstrating ability to use the mathematical underpinnings of quantum mechanics
3. Work with angular momentum operators and their eigenvalues both qualitatively and quantitatively
4. Use perturbation theory and other methods to find approximate solutions to problems in quantum mechanics, including the fine-structure of energy levels of hydrogen

Syllabus

1. **The Fundamentals of Quantum Mechanics** (6 lectures)
   - Postulates of quantum mechanics
   - Time evolution: the Schrődinger equation and the time evolution operator
   - Ehrenfest's theorem and the classical limit
   - The simple harmonic oscillator: creation and annihilation operators
   - Composite systems and entanglement
2. **Angular Momentum** (7 lectures)
   - General properties of angular momentum
   - Electron spin and the Stern-Gerlach experiment
   - Higher spins
   - Addition of angular momentum
   - Vector Operators
3. **Approximate methods I: variational method and WKB** (3 lectures)
   - Variational methods
   - WKB approximation for bound states and tunnelling
4. **Approximate methods II: Time-independent perturbation theory** (5 lectures)
   - Non-degenerate and degenerate perturbation theory
   - The fine structure of hydrogen
   - External fields: Zeeman and Stark effect in hydrogen
5. **The Einstein-Poldosky-Rosen "paradox" and Bell's inequalities** (1 lecture)