

Advanced Quantum Mechanics

Néda Sadooghi

Department of Physics
Sharif University of Technology
Tehran - Iran

Advanced Quantum Mechanics

Lecture 1: Introduction

1401-02-I

Info

- ▶ Books
- ▶ Exams and Homeworks
- ▶ Your grade (4+6+10 points)
- ▶ Course webpage in <http://sharif.edu/~sadooghi>

Lecture 1: Introduction

- Syllabus Quantum Mechanics I
- Syllabus Quantum Mechanics II
- Syllabus Quantum Mechanics III

Lecture 1: Introduction

Quantum Mechanics I

- Historical and experimental foundations
 - The wave function and the Schrödinger equation
 - Schrödinger equation in one dimension
 - General structure of wave mechanics; Vector spaces and operators
 - Operator methods in QM: **Harmonic oscillator**
 - Angular momentum; Raising and lowering operators
 - Schrödinger equation in three dimensions; Central potentials and the Hydrogen atom
- [Bound States in Three Dimensions]**

Lecture 1: Introduction

Quantum Mechanics II

- Matrix representation of operators
- Spin
 - The normal Zeeman effect
 - The Stern-Gerlach experiment
 - Pauli matrices, states and spinors
 - Magnetic moment
- Addition of angular momenta
 - The Clebsch-Gordan coefficients

Lecture 1: Introduction

Quantum Mechanics II

- Time independent perturbation theory
 - Non-degenerate and degenerate perturbation theory
 - The Stark effect
 - The real Hydrogen atom
 - Relativistic kinetic energy effects
 - Spin-orbit coupling
 - The anomalous Zeeman effect
 - Lamb shift
 - Hyperfine structure
- Identical particles (fermions and bosons)

Lecture 1: Introduction

Quantum Mechanics III: Part 1

F. Schwabl, *Quantum Mechanics*

Fourth Edition, Springer Verlag, 2007

Chapters 16, 17 and 18

Lecture 1: Introduction

Quantum Mechanics III: Part 1

F. Schwabl, *Quantum Mechanics*

Fourth Edition, Springer Verlag, 2007

Chapters 16, 17 and 18

► Time dependent phenomena

- Time dependent perturbation theory
- Transitions into a continuous spectrum, **Fermi's Golden Rule**
- Periodic perturbations
- Interaction with the radiation field
- Quantization of the radiation field
- Spontaneous emission

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Chapters 16, 17 and 18

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▶ The central potential

- The Schrödinger equation for a spherically symmetric square well
- Bound states of the spherical potential well
- Expansion of plane waves in spherical harmonics

Lecture 1: Introduction

► Scattering Theory

- Scattering of wave packet
- Scattering cross section
- Partial waves
- The optical theorem
- Born approximation
- Resonance scattering from a potential well
- ...

Lecture 1: Introduction

Quantum Mechanics III: Part 2

F. Schwabl, Advanced Quantum Mechanics

Fourth Edition, Springer Verlag, 2008

Chapters 1 + an extra manuscript

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▶ **Nonrelativistic Many-Particle systems**

- Second quantization of identical particles
- Bosons and fermions

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Chapters 1 + an extra manuscript

- ▶ **Nonrelativistic Many-Particle systems**
 - Second quantization of identical particles
 - Bosons and fermions
- ▶ **Path-integral (PI) formulation of quantum mechanics**
 - From the Schrödinger equation to PI
 - From PI to Schrödinger equation
 - Free particle
 - Harmonic oscillator
 - Some applications

Lecture 1: Introduction

Quantum Mechanics III: Part 3

F. Schwabl, *Advanced Quantum Mechanics*

Fourth Edition, Springer Verlag, 2008

Chapters 5, 6 and 7 (8)

- ▶ **Relativistic Quantum Mechanics [Selected topics]**
 - Klein-Gordon equation for scalar field
 - Dirac equation for fermions
 - Fermions and bosons in the presence of external magnetic fields