

课程大纲

COURSE SYLLABUS

1.	课程代码/名称 Course Code/Title	PHY5033 高等量子力学 B Advanced Quantum Mechanics B
2.	课程性质 Compulsory/Elective	专业核心课
3.	课程学分/学时 Course Credit/Hours	3/48
4.	授课语言 Teaching Language	英文/English
5.	授课教师 Instructor(s)	李贵新教授
6.	是否面向本科生开放 Open to undergraduates or not	否
7.	先修要求 Pre-requisites	General Physics
8.	教学目标 Course Objectives	<p>Quantum mechanics are essential to materials science and engineering at the atomic, molecular and crystal scales. Important optical, electrical, and magnetic properties of materials can only be well understood within the realm of quantum mechanics. This course is an introductory course for quantum mechanics with emphasis on applications in materials science. The objective is to provide students in materials science and engineering with basic concepts in quantum mechanics and apply the principles and methodologies to understand materials properties and device applications. Topics to be covered include Shrodinger's wave equation, Dirac notations, propagation in periodic potentials, quantum harmonic oscillators, and perturbation theory. By applying those quantum mechanical concepts, important materials properties and phenomena including crystal structures, electron propagation in crystals, molecular and lattice vibrations, and optical transitions are explained in detail. In addition, operation principles for semiconductor lasers and resonant tunnelling devices are discussed using quantum mechanical tools. After completing this course, students will have in-depth understanding of important materials properties and build a solid foundation to explore frontier materials research.</p>
9.	教学方法 Teaching Methods	<p>The course combines online lectures and classroom discussions for effective learning. Pre-recorded lecture videos will be placed online for students to study before the classroom discussions. The same lecture videos are available for students to review for multiple times to master the course materials. During classroom lectures, core concepts will be recapitulated to help students learn the topics. The knowledge points will be further clarified by answering and discussing student questions. To help establish the ability of applying the knowledge, numerous examples regarding to important material and device applications are illustrated by applying the concepts and theories of quantum mechanics. This "flipped" classroom approach is believed to help students develop an in-depth understanding of the course content.</p> <p>A final group project will provide another opportunity to the students to develop knowledge mining and knowledge application skills to address a current research topic related to quantum mechanics. The group project will also help students collaborate and work in a team environment. The term paper and project presentation will help students develop and hone their written and oral communication skills. This course is taught in English, including lectures, discussions, homework, exams, term papers and presentations.</p>
10.	教学内容 Course Contents	
	Section 1	Review of classical mechanics - 1D harmonic oscillator, diatomic molecule,

	monatomic and diatomic linear chains;
Section 2	Review of classical electromagnetism - electrostatics and electrodynamics;
Section 3	Toward quantum mechanics - Schrodinger wave equation, wave packet and dispersion, hydrogen atom, crystal structure, electronic structures of bulk semiconductors and heterostructures;
Section 4	Using the Schrödinger wave equation - normalization and completeness, currents due to tunnelling and traveling wave, symmetry and degeneracy
Section 5	Using the Schrödinger wave equation - particle in a box, transmission, reflection and tunnelling, nonequilibrium electron transistor;
Section 6	Electron propagation - propagation matrix, time-reversal symmetry, current conservation, rectangular potential barrier, resonant tunnelling;
Section 7	Electron propagation in a periodic potential - the Bloch's theorem, tight binding approximation, crystal momentum, effective mass, energy bands, the WKB approximation
Section 8	Eigenstates and operators - Dirac notation, the no cloning theorem, density of states;
Section 9	The harmonic oscillator - creation and annihilation operators, harmonic oscillator wave functions, time dependence
Section 10	The harmonic oscillator - quantization of electromagnetic fields, lattice vibrations and mechanical vibrations
Section 11	Fermions and bosons - Fermi-Dirac distribution and chemical potential, Bose-Einstein distribution function
Section 12	Time-dependent perturbation - first-order time-dependent perturbation, Fermi's golden rule, elastic scattering, photon emission
Section 13	The semiconductor laser - absorption, spontaneous and stimulated emissions, optical transition rules, gain in media, optical cavity
Section 14	The semiconductor laser - laser diode rate equations, numerical solution to rate equations, noise in laser diode emission
Section 15	Time-independent perturbation - time-independent nondegenerate and degenerate perturbations
Section 16	Angular momentum and the hydrogen atom - angular momentum operator, geometrical representation, spherical coordinates and spherical harmonics, rigid rotator
Section 17	Final exam

**11. 课程考核
Course Assessment**

Quiz: 5%
Homework: 20%
Midterm: 25%
Final exam: 35%
Project and presentation: 15%

**12. 教材及其它参考资料
Textbook and Supplementary Readings**

Textbook:

Applied Quantum Mechanics, Author: A. F. J. Levi, Publisher: Cambridge University Press 2nd ed. 2012, ISBN: 0521183995

References:

Quantum mechanics : concepts and applications, Author: Nouredine Zettili., Publisher: Wiley 2nd ed. 2009, ISBN: 9780470026793