Physics 3036 Quantum mechanics I

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3. Meeting time and venue

Lecture

Time: Tue, Thu 04:30 – 05:50 pm
Venue: G010, CYT Bldg

Tutorial

Time: Wed 3:30PM - 4:20PM
Venue: 1033 LSK (T1), 4504 (T2)

4. course description

Credit Points: 3

Pre-requisite: PHYS2022

Exclusion: PHYS 3037

Brief information

Basic properties of Schrodinger equation, bound and scattering states in simple one-dimensional potentials, formulation of quantum mechanics in terms of Hilbert space and Dirac bracket notation, Schrodinger equation in three-dimensions, angular momentum, hydrogen atom wavefunction, systems of identical particles, spin and statistics, multi-electron atoms and the periodic table.

5. Intended Learning Outcomes

On successful completion of this course, students are expected to be able to:

1. Explain the meaning of wavefunctions
2. Calculate the exact wavefunctions and energy levels of typical one-dimensional single particle problems

3. Represent quantum mechanical states as vectors in a Hilbert space

4. Predict possible outcomes of experimental observations on a quantum mechanical state
5. Analyze exact wavefunctions of the hydrogen atom and relate it to experimental observations
6. Describe orbital and spin angular momenta of an electron and their relation to experimental observations
7. Solve simple problems involving more than one non-interacting particles

6. Assessment scheme

Grading Scheme

Homework	20%
Midterm	25%
Quiz	5
Final	50%

Assessment marks for individual assessed tasks will be released within two weeks of the due date.

7. Student Learning Resources

Textbook: David J. Griffiths, Introduction to Quantum Mechanics, 2nd Edition, Prentice Hall (2005) or 3^{rd} Edition, Cambridge University Press (2018)

Lecture notes will be available on the course website before each lecture.

8. Teaching and learning activities

Lectures (3 hours) and tutorials (1 hour) focus on explaining the course topics.

9. Course Schedule

Lecture Schedule:

Lecture	Date	Content	Textbook Reference
1	4 Feb	Wave function and Born's interpretation; operators and first quantization rules	Ch. 1
2	6 Feb	Time-independent Schroedinger equation, stationary states, infinite square well potential	Ch. 2.1, 2.2
3	11 Feb	Quantum harmonic oscillator I	Ch. 2.3 (excluding solution by method, Sec 2.3.2)
4	13 Feb	Free particle and plane wave solutions, wave packets, phase and group velocities, time evolution of a wave packet	Ch. 2.4
5	18 Feb	Bound and scattering states; delta function well and barrier	Ch. 2.5
6	20 Feb	Finite square well	Ch. 2.6
7	25 Feb	Hilbert space	Ch. 3.1
8	27 Feb	Hermitian operators and observables	Ch 3.2, 3.3
9	4 Mar	Quantum measurement, position and momentum space representation of wavefunctions	Ch 3.4
10	6 Mar	Simultaneous measurements and uncertainty principle; conservation laws	Ch 3.5 (excluding minimum u wavepacket, Ch 3.5.2)
11	11 Mar	Conservation laws; energy-time uncertainty principle; philosophical issues of QM	Ch 3.5.3
12	13 Mar	QM in a finite dimensional Hilbert space	Ch 3.6
13	18 Mar	SE in 3D under central potential; radial and angular equation; solution to angular equation	Ch 4.1

14	**20 Mar**	**Visualizing spherical harmonics; radial equation**	**Ch 4.1**
15	**25 Mar**	**Hydrogen atom wave function and electron density**	**Ch 4.2 (excluding series soluti equation, Griffiths Eq. 4.62 to**
16	**27 Mar**	**Eigenvalues of angular momentum by algebraic method**	**Ch 4.3, 4.3.1**
17	**8 Apr**	**Orbital angular momentum, its eigenfunctions, eigenvalues and their interpretation**	**Ch 4.3.2**
18	**10 Apr**	**Spin angular momentum**	**Ch 4.4, 4.4.1**
19	**15 Apr**	**Spin angular momentum in an external magnetic field, Larmor precession, Stern-Gerlach experiment**	**Ch 4.4.2**
20	**17 Apr**	**Addition of angular momenta, coupling of two spin-1/2 objects, singlet and triplet**	**Ch 4.4.3**
21	**22 Apr**	**Addition of angular momenta, Clebsh-Gordon coefficients**	**Ch 4.4.3**
22	**24 Apr**	**Two-particle systems; bosons and fermions**	**Ch 5.1-5.1.1**
23	**29 Apr**	**Exchange force; electrons in covalent bond**	**Ch 5.1.2**
24	**6 May**	**Hydrogen-like atoms; Helium**	**Ch 5.2-5.2.1**
25	**8 May**	**Multi-electron atoms, periodic table**	**Ch 5.2.2**

Mapping of Course ILOs to Assessment Tasks

Assessed Task	**Mapped ILOs**	**Explanation**
Homework	ILO1, ILO2, ILO3, ILO4, ILO5, ILO6, ILO7	This task assesses students' ability to explain the meaning of wavefunctions (ILO 1), compare

		and contrast exact wavefunctions of typical one-dimensional single particle problems (ILO 2), treat quantum mechanical states as vectors in a Hilbert space y (ILO 3), predict possible outcomes of experimental observations on a quantum mechanical state (ILO 4), analyze exact wavefunctions of the hydrogen atom and relate it to experimental observations (ILO5), describe orbital and spin angular momenta of an electron and their relation to experimental observations (ILO6) and solve simple problems involving more than one non-interacting particles (ILO7).
Midterm	ILO1, ILO2, ILO3, ILO4, ILO5, ILO6, ILO7	This task assesses students' ability to explain the meaning of wavefunctions (ILO 1), compare and contrast exact wavefunctions of typical one-dimensional single particle problems (ILO 2), treat quantum mechanical states as vectors in a Hilbert space y (ILO 3), predict possible outcomes of experimental observations on a quantum mechanical state (ILO 4).
Final	ILO1, ILO2, ILO3, ILO4, ILO5, ILO6, ILO7	This task assesses students' ability to explain the meaning of wavefunctions (ILO 1), compare and contrast exact wavefunctions of typical one-dimensional single particle problems (ILO 2), treat quantum mechanical states as vectors in a Hilbert space y (ILO 3), predict possible outcomes of experimental observations on a

		quantum mechanical state (ILO 4), analyze exact wavefunctions of the hydrogen atom and relate it to experimental observations (ILO5), describe orbital and spin angular momenta of an electron and their relation to experimental observations (ILO6) and solve simple problems involving more than one non-interacting particles (ILO7).
Quiz	ILO1, ILO2, ILO3, ILO4, ILO5, ILO6, ILO7	This task assesses students' ability to explain the meaning of wavefunctions (ILO 1), compare and contrast exact wavefunctions of typical one-dimensional single particle problems (ILO 2), treat quantum mechanical states as vectors in a Hilbert space y (ILO 3), predict possible outcomes of experimental observations on a quantum mechanical state (ILO 4), analyze exact wavefunctions of the hydrogen atom and relate it to experimental observations (ILO5), describe orbital and spin angular momenta of an electron and their relation to experimental observations (ILO6) and solve simple problems involving more than one non-interacting particles (ILO7).

Final Grade Descriptors:
[As appropriate to the course and aligned with university standards]

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Demonstrates a comprehensive grasp of quantum mechanics, expertise in solving the Schrodinger equation, interpreting the wavefunction for the potentials covered in the course and related potentials,

		and predicting outcomes of experimental observations on a quantum mechanical state.
B	Good Performance	Shows good knowledge and understanding of quantum mechanics, competence in solving the Schrodinger equation and interpreting the wavefunction for the potentials covered in the course and related potentials, and predicting outcomes of experimental observations on a quantum mechanical state.
C	Satisfactory Performance	Possesses adequate knowledge of quantum mechanics, solving the Schrodinger equation and interpreting the wavefunction for the potentials covered in the course and related potentials, and predicting outcomes of experimental observations on a quantum mechanical state.
D	Marginal Pass	Has threshold knowledge of quantum mechanics, solving the Schrodinger equation and interpreting the wavefunction for the potentials covered in the course and related potentials, and predicting outcomes of experimental observations on a quantum mechanical state.
F	Fail	Demonstrates insufficient understanding of quantum mechanics, solving the Schrodinger equation and interpreting the wavefunction for the potentials covered in the course and related potentials, and predicting outcomes of experimental observations on a quantum mechanical state.

	Excellent	Good	Satisfactory	Marginal	Final
Homework. Midterm, Final Exam	Exhibits a thorough understanding of quantum mechanics, proficiency in solving the Schrödinger equation, interpreting wavefunctions for the potentials	Displays solid understanding of quantum mechanics, competency in solving the Schrödinger equation, interpreting wavefunctions for the potentials	Has a sufficient understanding of quantum mechanics, capability in solving the Schrödinger equation, interpreting wavefunctions for the potentials discussed	Possesses basic understanding of quantum mechanics, limited capability in solving the Schrödinger equation, interpreting wavefunctions for the potentials	nadequate understanding of quantum mechanics, struggles in solving the Schrödinger equation, interpreting wavefunctions for the potentials discussed in the

	discussed in the course and similar potentials, and forecasting the results of experimental observations related to a quantum mechanical state.	discussed in the course and similar potentials, and forecasting the results of experimental observations related to a quantum mechanical state.	in the course and similar potentials, and forecasting the results of experimental observations related to a quantum mechanical state.	discussed in the course and similar potentials, and forecasting the results of experimental observations related to a quantum mechanical state.	course and similar potentials, and forecasting the results of experimental observations related to a quantum mechanical state.

Course AI Policy

Students can use generative in learning the course material, but not in doing the homework assignment.

Communication and Feedback

Assessment marks for individual assessed tasks will be communicated via Canvas within two weeks of submission. Students who have further questions about the feedback including marks should consult the instructor within five working days after the feedback is received.

Required Texts and Materials

David J. Griffiths, Introduction to Quantum Mechanics,
2nd Edition, Prentice Hall (2005)
QC174.12 .G75 2005
or
3rd Edition, Cambridge University Press (2018)
QC174.12 .G75 2018

Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to Academic Integrity | HKUST – Academic Registry for the University's definition of plagiarism and ways to avoid cheating and plagiarism.